PRODUCT ENGINEERING

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Contents for July, 1932

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PRODUCT ENGINEERING

MCGRAW-HILL PUBLISHING CO., INC. VOLUME THREE, NUMBER SEVEN

JULY, 1932

Graphical Analysis of Impact in Mechanical Movements

GEORGE F. NORDENHOLT
Associate Editor

With the ever increasing demand for speed, the minimizing of acceleration forces and impact becomes of greater importance. Both the magnitude and the rapidity of fluctuation of the forces in mechanical movements can be analyzed graphically by this simple method

▲

In the analysis of mechanisms as ordinarily presented in textbooks, the only elements dealt with are displacement, velocity, and acceleration. Also, in the design of movement these are usually the only factors considered by the designer. The displacements required are dictated by the design, and if the engineer considers it of importance, he will determine the acceleration forces involved. In most instances, this is all that is required, but when designing relatively light machines or machines to handle delicate things, particularly at high speeds, not only the magnitude of the forces, but also impact, becomes important.

In the final analysis, the magnitude of the forces involved in the mechanism is not the only factor that determines its success or failure. Machine elements can usually be made sufficiently strong to resist any forces within reason, and by the use of light strong alloys, the inertia forces can be reduced. But in order to have the mechanism operate smoothly, free from shocks, it is also required that the rate of change of the forces actuating the mechanism shall be kept within limits. In other words, impact being a suddenly applied force, it can be considered as the result of a tremendously rapid increase in the applied force. It is the purpose of this article to demonstrate the effects of a rapid change in acceleration and to show how the magnitude of this quantity can be obtained in a simple graphical manner.

Undoubtedly the most commonly used time-displacement curves for mechanical movements are those representing harmonic motion, or a modification thereof. The pure harmonic type of motion is represented by the familiar Scotch Yoke, and for convenience, the curves of displacement, velocity and acceleration, all with respect to time, as obtained by the Scotch Yoke, are shown in Fig. 1.

Reviewing the equations for harmonic motion, we have for the time-displacement curve:

$$s = r - r \cos \omega t$$

r = crank radius
ω = angular velocity in radius per sec.
t = time in sec.
$\theta = \omega t$ = angular displacemt of crank
s = displacement of crosshead

Taking the derivative of this expression, we get for v, the velocity:

$$v = r \sin \omega t$$

The second derivative gives the acceleration a of the crosshead:

$$a = - r \omega^2 \cos \omega t$$

In plotting the curves for Fig. 1, the values of r and ω were assumed as being equal to unity, the curves being merely for the purpose of illustrating their general character.

In the consideration of a problem in cams, linkages, or mechanisms for automatic motions, the designer is primarily concerned with the smoothness of operation. As explained above, smoothness of operation is not a question of the magnitude of the forces involved, but rather the rate at which the forces change. Thus if the forces actuating a certain mechanism fluctuate at an extremely rapid rate, it will result in impact and possibly some vibration. Of course, the degree of importance of this factor

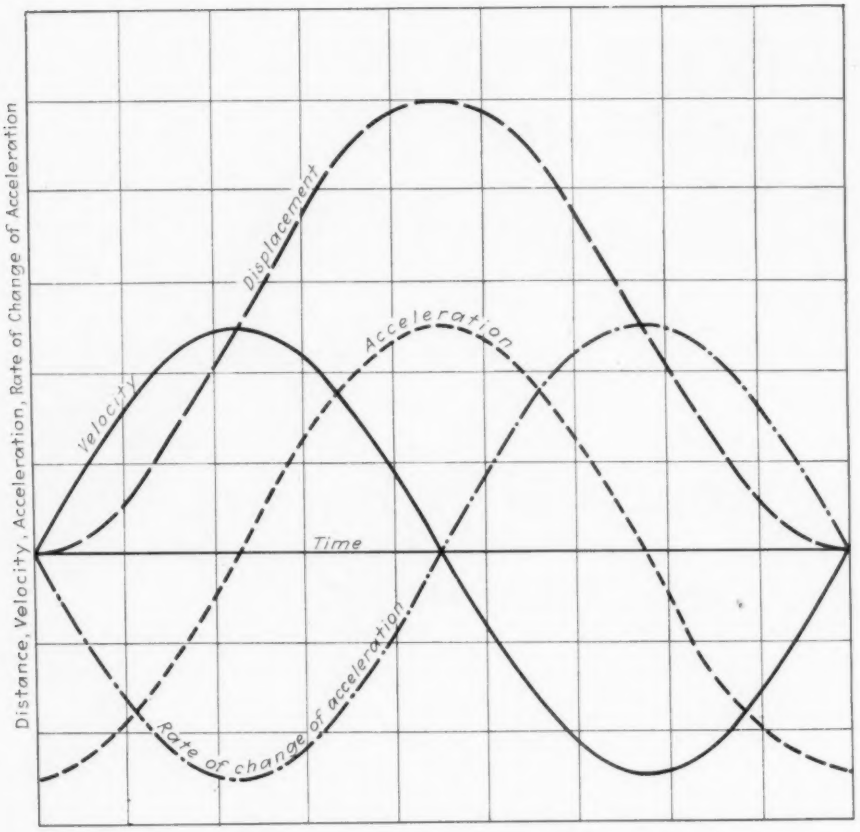


Fig. 1—Rate of change of acceleration is sometimes a controlling factor in the operation of an automatic mechanism. In these curves of pure harmonic motion, the rate of change of acceleration is shown by the dot-and-dash lines

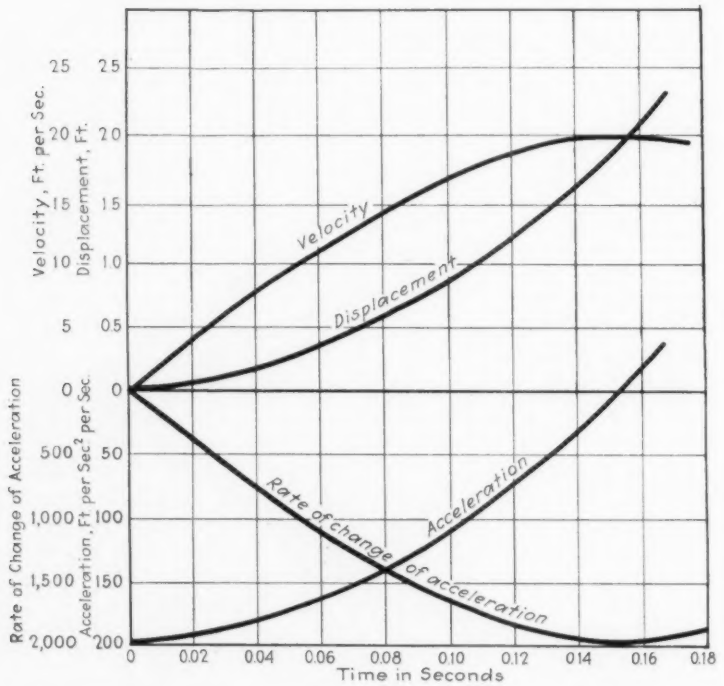


Fig. 2—Merely an inspection of the appearance of the curves might lead to wrong conclusions. As indicated by the scales, even with pure harmonic motion, the rate of change of acceleration can be great, possibly resulting in impact

depends largely on the type of mechanism, and in heavy, slow-moving machines, it probably would not have any big bearing on the problem. But in the average machines employing automatic motion and where delicate operations are to be performed, the question of impact forces might be of prime importance, particularly when the velocities are large. Even a relatively light blow exerted by an automatically operated guide or lever upon a delicate thread, such as rayon in the process of manufacture, might cause breakage.

As the rate of change of force is directly proportional to the rate of change of acceleration, it follows that the derivative of the equation of acceleration will give the curve representing the rate of change of the forces. Carrying through this operation, we have:

$$i = -r\omega^3 \sin \omega t$$

Here i represents the rate of change of the accelerating force. As this curve is the first derivative of the equation of acceleration, it is evident that the steepness of the curve of acceleration is a measure of the rate of change of the accelerating force. The curve showing the rate of change of acceleration is also plotted in Fig. 1, to conveniently show the relation between the four curves; space, velocity, acceleration, and rate of change of acceleration.

It is sometimes assumed that because harmonic motion is used, the motion will be smooth and free from jarring. Also, one is apt to be deceived by the smooth appearance of the curves. It must be recognized that by decreasing the time scale, the harmonic curves will be made steeper. Therefore it is evident that by selecting a large unit for the scale of time, the curves can be given a flat appearance. Hence merely the appearance of the curves is no criterion of the smoothness of operation that will be obtained. But by plotting the "rate of change of force" curve, the designer will be able to read from the scales not only the magnitude of the forces involved, but also the rate at which these forces change at every point in the cycle of motion. Furthermore, in some instances by modifying the curves the engineer can select the points in the cycle where maximum acceleration and change of rate of acceleration are to occur, selecting the most favorable points in the cycle. Working backwards, the mechanism would be modified accordingly.

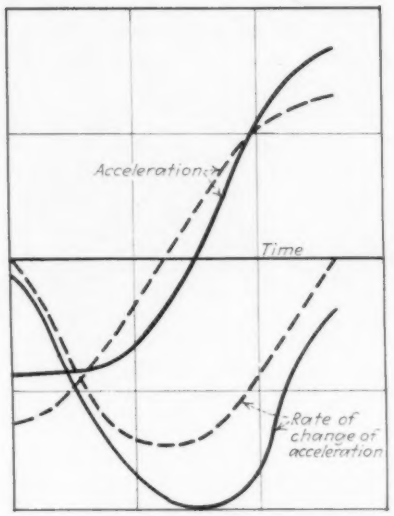


Fig. 3—The dashed curves are for pure harmonic motion, the solid curves for a slider-crank mechanism with a 3½ to 1 ratio of rod to crank

In plotting the derivative curves, it is not necessary to first differentiate the original expression, and then plot the resulting curve. In many instances, the velocity and acceleration curves become extremely complex, making it rather difficult to either differentiate them or plot them. Furthermore, the displacement and velocity curves are frequently irregular. The derivative curves can be obtained graphically in a simple manner. In order to construct the derivative curves graphically, a tangent is drawn to the given curve at the abscissa for which the value of the ordinate is to be found. The tangent of the angle that this line makes with the *X* axis will be the value of the ordinate. The simplest method is to let the tangent be the hypothenuse of a triangle, the base of which is a unit of time or a decimal thereof. The altitude of this triangle can then be read off of the ordinate scale, and divided by the period of time represented by the base of the triangle, will give the value of the desired ordinate which can then be plotted.

[For a more detailed explanation and description of instruments for performing these operations rapidly, see article by J. M. Barr, "Mechanizing the Calculus," *P.E.*, p. 569, December, 1930.]

To illustrate the manner of handling numerical values, the curves shown in Fig. 1 have been replotted, using a crank radius of unity and an angular velocity of 10 radians per sec. In order to keep down the height of the curves, different scales are used for the different ordinates, the scale for velocity being ten times that of displacement, and the acceleration and rate of change of acceleration curves each being successively multiplied by ten. As can be seen from an inspection of the equations, this will cause the maximum ordinate of each of the last three curves to be equal to each other, because the scale multiplication factor chosen happens to represent the angular velocity in radians per sec. Furthermore, it will be noticed that in this group of harmonic curves, the maximum values of acceleration and rate of change of acceleration can be obtained by multiplying linear velocity successively by the angular velocity in radians per sec. This does not hold for all types of motion curves, it being one of the peculiarities of harmonic motion.

It will be noticed that neither the acceleration nor the rate of change of acceleration scales read in units of force. However, by multiplying the acceleration by the mass of the moving element, the corresponding force is obtained. Likewise, the same computation with respect to the rate of change of acceleration will give the rate of change of the force at the given instant. Thus, for the curves in Fig. 2 and assuming a weight of 3.2 lb. or a mass of 0.1 lb. per ft. per sec. per sec., the maximum force acting will be 20 lb. and the maximum rate of change of force acting will be 200 lb. per sec., this last taking place at the instant that the acceleration curve passes through zero.

So far only harmonic motion has been considered. But the crank and connecting rod mechanism, which is a common construction, does not give pure harmonic motion, the curves being distorted more and more as the ratio of the length of the connecting rod to the crank radius decreases. In Fig. 3 is shown the acceleration curve for a slider-crank mechanism having a ratio of connecting rod to crank of 3½ to 1. The true harmonic curve is shown in dotted lines.

In this same figure are superimposed the harmonic and actual curves for rate of change of acceleration. It will be noticed that the maximum rate of change of acceleration for the slider-crank mechanism with a 3½ to 1 ratio of connecting rod to crank, is about 33 per cent more than that for true harmonic motion. Furthermore, the maximum force involved is about 30 per cent more. In crank mechanisms with relatively shorter connecting rod, these figures will be increased considerably. Undoubtedly many instances of failure of this type of mechanism to operate satisfactorily can be traced to a short connecting rod.

In addition to the problems concerning slider-crank mechanisms, many linkages involve rectilinear motions wherein the direction of travel is changed. The principles of harmonic motion can be applied here also, but in many designs it is possible to get smoother operation and lower forces by using other types of curves.

One such curve, well known among civil engineers, is Eulers spiral. The property of this curve is that the ra-

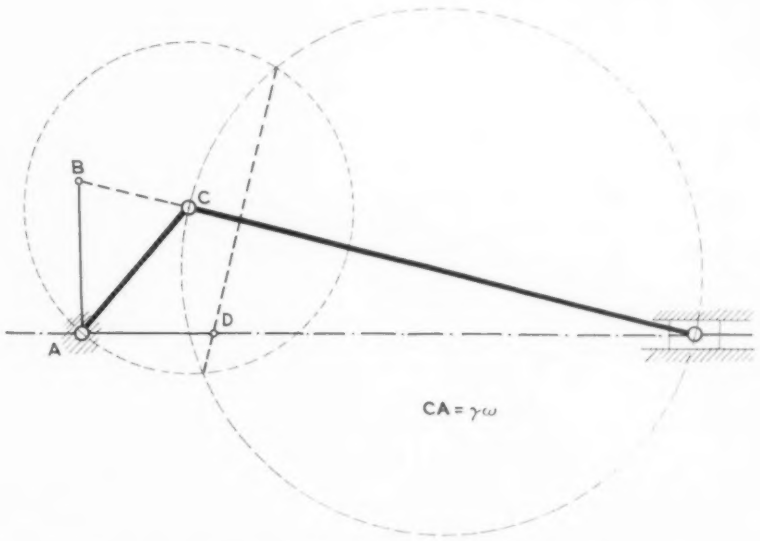


Fig. 4—By means of this simple construction, the velocities and accelerations for a slider crank mechanism can be obtained graphically. This is known as Klein's construction

dius of curvature at any point is inversely proportional to the length of the arc. The equation of the curve is:

$$R\,s = C$$

In this equation, R is the radius of curvature, s the length of the curve,

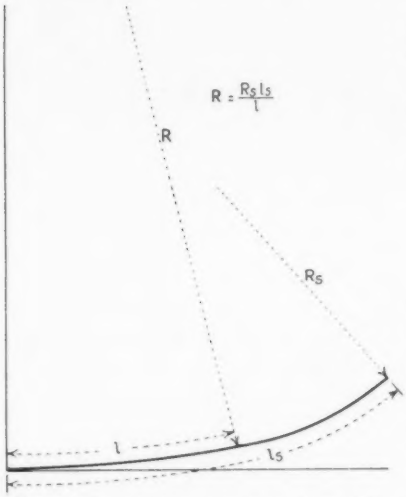


Fig. 5—Transition spirals such as this give an extremely low rate of change of acceleration but relatively small displacement.

and C is a constant. The general appearance of this curve is shown in Fig. 5. Its exact construction is rather laborious and requires a lengthy explanation. Detailed information regarding it and the method for constructing the curve can be found in handbooks on railway and road construction. This curve, known as a transition curve or spiral, is used extensively for laying out the curves of railroad tracks and highways.

Another curve, simpler to construct and also commonly used in railroad work and road building, is the familiar parabola. The equation of this curve is represented by:

$$y = k\,x^2$$

This curve is relatively easy to plot and even simpler to lay out graphically.

Referring to Fig. 6, let it be assumed that it is desired to construct a cam that will give horizontal travel to a roller moving from left to right at a uniform velocity. At the point A the roller is to move along a curve to point B from which point it will continue with uniform horizontal travel to the right. Reversed parabolas could be used for the path of travel from point A to point B. The construction of these parabolas can be done graphically as follows:

Draw the line AB, and locate the quarter points C, M, and C'. Draw the perpendicular CV, and extend $A'A$ to V. Join V and M. Similarly, construct the isosceles triangle $MV'B$. Locate E, the midpoint of line CV. This will be one point on the parabola.

To obtain other points on the parabola, divide AV into any number of convenient parts, such as four, and draw lines 1-1′, 2-2′, and 3-3′, parallel to CV. The distance 1-1′ will equal $\frac{1}{16}\,EV$, 2-2′ will equal $\frac{1}{4}\,EV$, and 3-3′ will equal $\frac{9}{16}\,EV$. That is:—

$$1\text{-}1' = \left(\frac{A\text{-}1}{A\ V}\right)^2 \times E\,V$$

Assuming that the roller is to ride on the path $AEME'B$ at a known velocity in the horizontal direction, the vertical ordinate measured from the line $A'V$ extended, will be the distances travelled vertically. The curve $AEME'B$ can therefore be used as the space-time curve, with the line AV as the X axis. The acceleration and rate of change of acceleration curves can then be constructed graphically as explained previously.

The rate of change of acceleration curve used in the operation of elevators is given by the expression:

$$\frac{da}{dt} = K \text{ (a constant)}$$

Hence,

$$a = kt$$

This curve is a straight line whose slope is k. The velocity curve will be the parabola:

$$v = \tfrac{1}{2}\,kt^2$$

Taking the integral of this expression, we get for the distance or displacement:

$$s = \tfrac{1}{6}\,kt^3$$

In the above discussion only the three fundamental types of motions have been considered, namely, pure harmonic, the slider-crank mechanism, and the change of direction of rectalinear motion. The principles can be applied to any type of mechanism regardless of how complex it may be. With reference to the question as to the best type of mechanism to be employed, conditions will usually restrict the designer to the choice of a limited few. It is then up to him to select the most suitable one, basing his choice on the results of an analysis of the forces involved and their rate of change.

Naturally the question arises as to the permissible magnitude of the impact forces or the maximum rate of change of applied forces. It is impossible to establish the numerical quantities for this factor as the character of the design and the mass of the moving parts will have a great effect. However, by the use of the analysis discussed above, it will be possible to establish the curves representing the rate of change of the applied forces for various machines and mechanisms in actual operation, and in that way establish a basis of comparison.

To plot the velocity and acceleration curves for the slider-crank mechanism, much time can be saved by using the direct graphical method of scaling the quantities off skeleton diagrams of the mechanism in the different crank positions. Referring to Fig. 4, the method of constructing which is evident, if the length AC is drawn to a scale to represent the linear velocity $r\omega$ of the crankpin, the length AB will represent the velocity of the slider or crosshead, and the length AD will represent the acceleration of the crosshead, for the indicated position of the crank. The proof of this, known generally as Klein's construction can be found in textbooks on the subject of mechanisms.

Similarly for other types of mechanisms it is usually easier and more accurate to obtain both the displacement curve and the velocity curve by graphical methods and from the latter construct the acceleration and rate of change of acceleration curves.

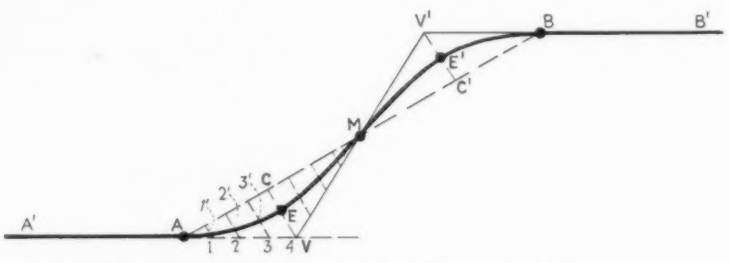
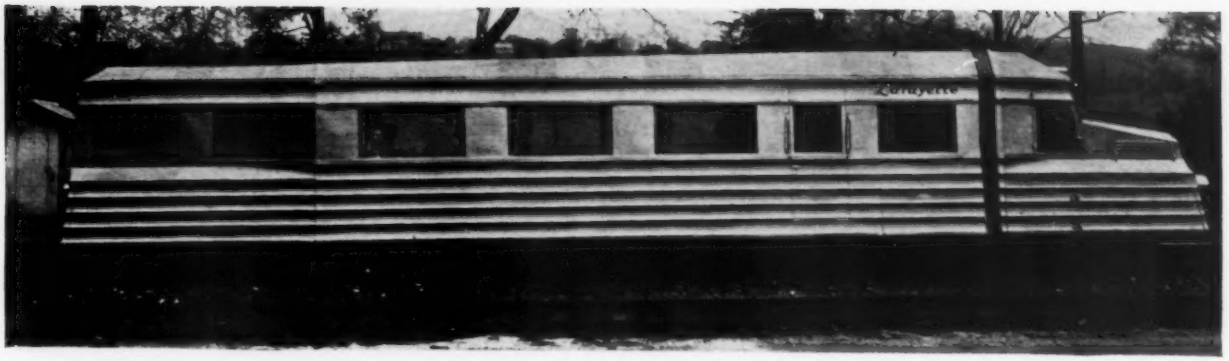


Fig. 6—In moving from the path *AA′* to *BB′*, the parabola can be used being constructed graphically as explained in the text.



This special Budd-Micheline rail-car will be placed in service on the French National Railways. It is constructed largely of shot-welded stainless steel and runs on pneumatic tires. The weight is but 11,000 lb., and the capacity is 30 passengers

PRODUCT DEVELOPMENTS

▸ New Material Uses

Heat-treated chrome-molybdenum steel tubing, with all joints welded, constitutes the frame of the Metlab aircraft-type bus seats of Metallurgical Laboratories, Inc. Upholstery springs are replaced by air-filled cushions covered with a 2-in. thickness of tufted curled hair. These seats weigh 40 to 60 per cent less than standard equipment yet are designed to withstand 1,000 lb. static load.

Nickel-molybdenum steel is the material selected by Sullivan Machinery Co., for its new coal-mining cutter chain. Strap links as well as cutter links are drop forgings.

Ridgely Trimmer Co., adopts Everdur metal for scraping knives designed to clean gasoline tank cars. Steel has been found to spark on occasion with disastrous results. For the same reason plus corrosion-resistance this non-ferrous material is now going into shovels used to handle explosive or corrosive materials. The shovels are giving long service in handling acid sludge.

Since steel tanks have been found to corrode in service with certain types of gasoline, Coleman Lamp & Stove Co. is fabricating a special lot of 500 1-gal. Everdur tanks to be used as fuel containers for gasoline stoves. Everdur is also being pressed into service for DuPont dynamite mixing bowls, 10 ft. 4 in. diam. and 24 in. deep to displace laminated wood. Lukens Steel Co. is fabricating them out of circular plates 132 in. diam. and $\frac{3}{4}$ in. thick. There must be no sparks around dynamite.

Seamless solid copper caskets are being formed on molds hung in an electrolytic bath by National Casket Co. After 80 hours of immersion, the tops and bottoms emerge with every detail of the design complete. Both the design and the process are protected by patents.

The new line of Remington-Rand safe-cabinets, of which this is one model, finds itself still further removed from the old fashioned, angle-bound iron safe in appearance but not in security

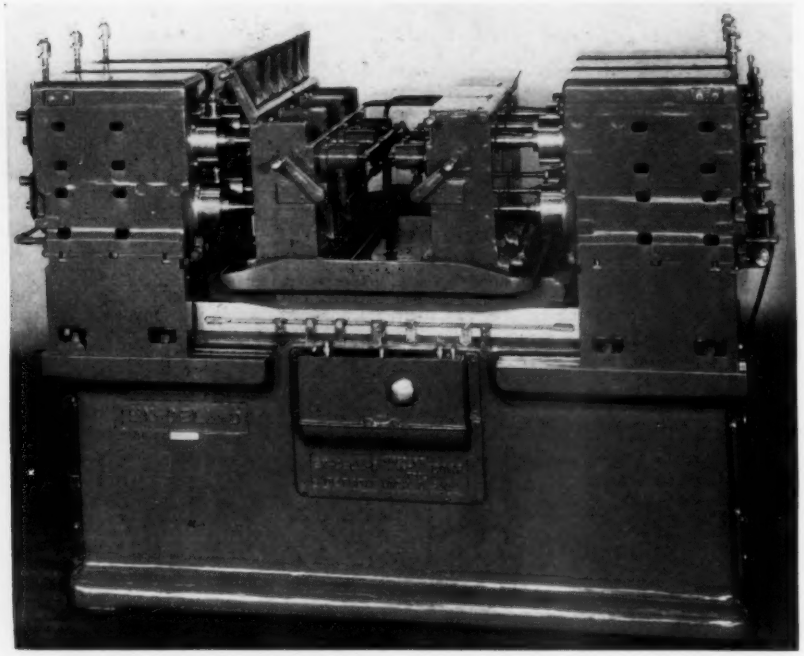
Aluminum alloy goes into mine service in a portable slat conveyor developed by Duncan Foundry & Machine Works, Inc. Though the chain, the flights, the motor and certain minor parts are steel, the total weight of the machine is but 980 lb., 41 per cent less than an all steel conveyor of similar size and capacity.

Newest material for automobile tops is sheet copper produced electrolytically by Raritan Copper Works. The body builders back the 0.0017-in. metal with fabric held on by suitable adhesives. It is said that the sheeting can be made to resemble leather by crimping and painting. It should make an efficient radio aerial.

General Cable Corp. becomes exclusive American licensee to use Thiokol as insulation for a line of electric conductors. Thiokol is the olefin-polysulfide reaction product described in a recent issue of *P. E.* as having all the electrical insulation characteristics of rubber plus resistance to oils, alkalis and acids.

Westinghouse Electric & Mfg. Co. is about to feature Everdur in the tanks of a new line of electric water heaters.

Canadian Pacific's new "8000" locomotive, developed jointly by C. P,. New York Central, American Locomotive Co. and the Superheater Co., carries a three section boiler. One section is designed for 250 lb. pressure and is built of standard 2



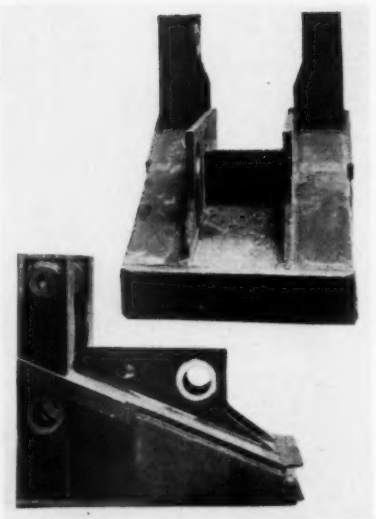
The designers of Excello Style 216A precision diamond boring machine have sought and achieved a straight line effect. All joining surfaces are properly matched, and all sharp edges machined to ⅛ in. radius. With a pedestal foot type of base, no chips, dirt or water can collect and be held on the base proper. With the set-up shown, the machine will bore both ends of a connecting rod in one operation

to 3 per cent nickel steel plate. The second section must withstand 800 lb., and the third, a closed heat-transfer system, 1400 lb. For these two sections 3½ per cent nickel steel forgings are brought into what might be called super-service.

A solution developed by Bakelite Corp. is intended for sealing castings, and after proper treatment it is impossible to melt or dissolve it out. The material is unaffected by hot or cold water, by steam, or by temperatures up to 400 deg. F., and is resistant to most chemical reagents.

Patent is pending on the use of sapphire jewels, like those used in watches, as channels in the nozzle through which the oil passes in the Quiet May oil burner. The May Co. claims that the jeweled orifice maintains its precision regardless of the quality or grade of fuel oil used.

Sponge rubber finds another job as the grip or handle covering of the Westinghouse de luxe Adjust-o-matic electric laundry iron, shown for the first time at the N.E.L.A. convention and exposition.



Side and top views of arc-welded steel counterweight bracket made by the Wellman Engineering Co., Cleveland, O., and reported by the Lincoln Electric Co. These welded steel brackets, used on revolving car dumpers, were formerly made of cast iron, and were designed to function properly at their casting weight of 4,000 lb. each. The problem of obtaining this same weight in arc-welded construction was solved by pouring1,250 lb. of cement mixed with steel punchings into the space provided. The cement was poured before the last plate was welded on

In the bottom of the hopper of the new Abbott ball "speed-loader," which is designed by the Abbott Ball Co. for use in connection with loading burnishing barrels, four gates will be found fabricated out of stainless steel. The same material is used in a corrosion-resistant guide for conveyor buckets in the same device.

The Bossert Corporation announces the "Hydrocrat—successor to the sink," a domestic kitchen sink made of Enduro stainless steel.

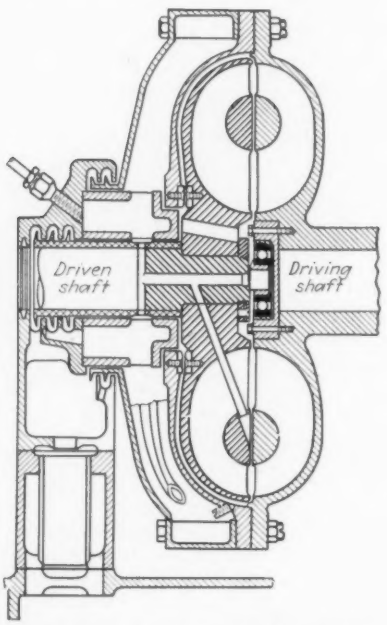
For light weight, appearance and sound-deadening quality, aluminum is the material chosen by Barber Colman Co. for its new Barcol two-bladed, airplane type electric household and office fan. The base and motor case are of a molded composition.

▸ New Applications of Parts and Units

S. M. Howes Co. utilizes a universal motor to turn the dasher in its latest ice cream freezer. This model is designed to slip into the freezing compartment of any mechanical refrigerator in place of the ice cube trays.

Pneumatic tires continue to invade the railway field, this time in Firestone 48 x 12 low pressure rail tires designed for a four-wheel-drive switching tractor. Six-ply, the tires carry 15 lb. pressure.

A photo-sensitive plate positioned between the two automobile headlights will dim them on the approach



Power is transmitted through this coupling, designed by Hydraulic Couplings, Inc., by the kinetic energy of the oil discharged by impeller on the right against the vanes of the runner. Oil circulates out through "scoop" tube at lower left of runner, to gravity tank, over an adjustable weir and back to impeller. Height of weir adjusts speed of driven shaft by regulating amount of oil in the coupling

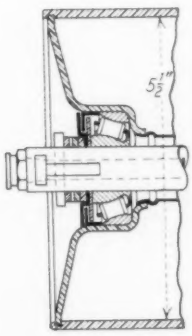
ot passing automobiles. Serge Vassilake, Paris, France, the inventor, claims that his device is so sensitive that it can be adjusted to dim when on-coming lights are 400 meters off. Despite this automatic control, the driver may flash his lights off and on at will.

A shaded pole, induction disk, fixed speed motor furnishes the motive power to the Reco Neonimator of Reynolds Electric Co., said to be the first motor driven flasher for neon signs. The device acts on the high voltage or secondary side of neon transformers. Each circuit will carry up to 30 milliamps at 15,000 volts.

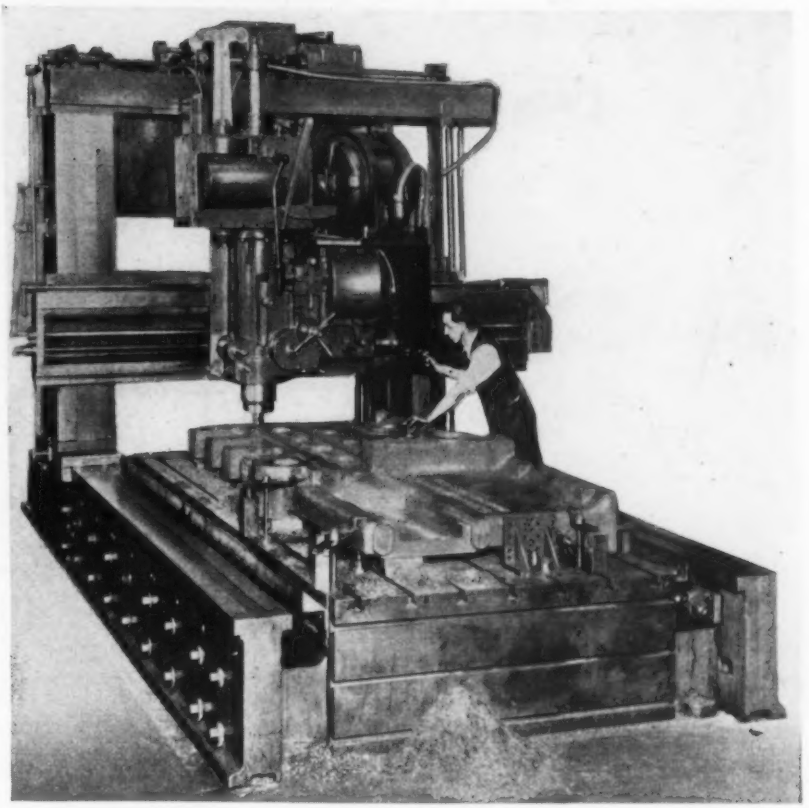
Twin, rather than single, loud speakers will be found in certain 1933 "quality" models of 72 per cent of the radio manufacturers. 95 per cent of them will utilize the new series of six-prong radio tubes to the exclusion of current models. Visual tuning indicators, or meters, will be used by 48 per cent of the manufacturers as against 12 per cent for 1932. And consoles are coming back strong.

Not power, but water is transmitted by two rubber V-belts in the Klenzair portable air-washing and air-cooling fan of The Swartzbaugh Mfg. Co. Running loosely over rotating metal disks, the belts dip their free loops into a water reservoir, carry water to the disks which in turn throw minute drops tangentially by centrifugal force. A fan blows air through the mist with consequent cooling and humidifying.

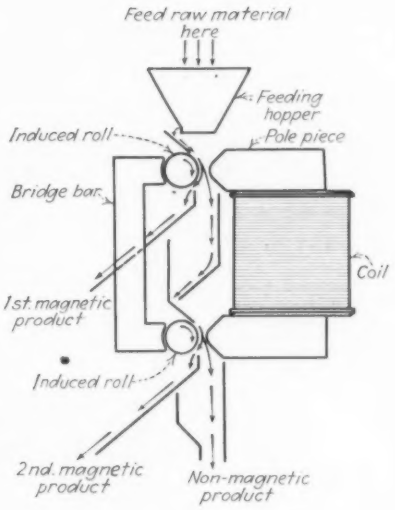
Electric glue heaters brought out by Divine Brothers Co. are equipped with thermostats. The control apparatus comprises a heat-sensitive element in the bath, which controls the position of a contactor mounted on a panel board. This contactor energizes a relay that controls the flow of electric current to the heating element. Tests show that glue can be held within 2 deg. F. of the desired temperature.



In the anti-friction conveyor carrier just announced by the Barber - Greene Co. the Shafer roller bearings are held in by labyrinth seal washers, shimmed to keep bearings tight. For adjustment, remove taper pin, insert additional shim, and replace pin



In the Sleeper & Hartley universal milling machine, the housing travels on the fixed bed, being moved along the ways by a screw. Base and side frames are each one-piece castings of box-type construction with internal bracing. Side frames are gibbed to track with binders to prevent lifting. All feeds are motorized. The vertical spindle, mounted in anti-friction bearings, is driven by a 4-speed 10-hp. motor on the frame



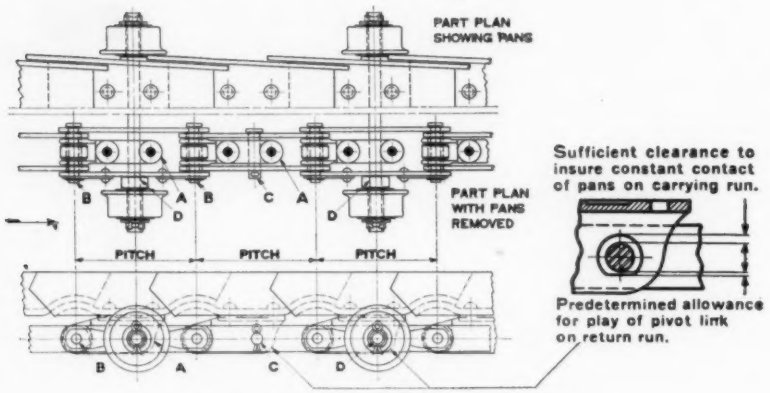
▸ To Separate Feebly Megnetic Materials

Details become available on a magnetic separator designed to combine great capacity with a separating intensity heretofore considered unattainable. The laboratories of Dings Magnetic Separator Co. attest that the Dings Type IR performs the following operations: removes slate from coal, mica from feldspar, iron oxide from bauxite, dolomite from gypsum, oxides of iron and imbedded oxide particles from silica, sand, etc. Though not generally known, there are forty or more minerals in addition to iron that are magnetic to a certain degree.

In the accompanying diagram will be seen the massive horseshoe-type electro-magnet. Interposed between the tapered pole pieces and the bridgebar, or keeper, are laminated rolls, one opposite each pole. To reduce flux resistance there is a minimum of space between the keeper and rolls, the lines of magnetic force being concentrated almost completely in the two air-gaps between the rolls and the poles. These magnetic zones present a field strength of 18,000 gauss.

Material to be separated flows by gravity onto the upper induced roll. As this roll is made of magnetic iron,

The new oil and dirt seal for Caterpillar tractor rear end drives incorporates a spring-loaded "Sylphon" bellows with cork faces bearing against chromium plated washer plates



Detail of the "Gravity Seal" apron conveyor

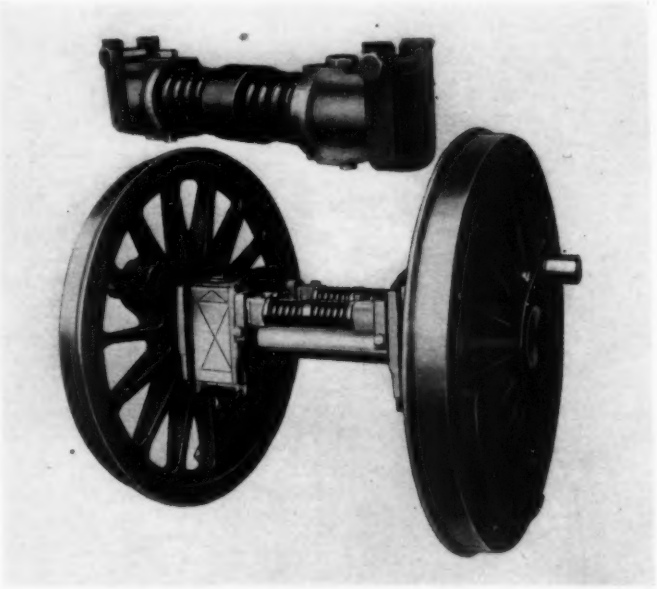
the magnetic portion of the material is drawn to the surface of the roll where it is held until the roll passes bottom dead center. The separated material drops off when the lines of force are reversed and is carried away by an inclined chute. Even with the most feebly magnetic substances, the first roll will remove the majority of the magnetic portion. The remainder of the material passes downward and is again subjected to the same separation process on the second roll.

▸ "Gravity Seal" Steel Apron Conveyor

Applicable alike to apron conveyors and apron feeders, the patented pivot link so attaches the pans to the chains that the new "Gravity Seal" conveyor of The Webster & Weller Mfg. Companies, will not leak dry materials and yet will travel around the sprockets without strain. In the accompanying drawing it will be seen that the pans are attached through the pivot links *A* to the chain pins *B* and that they have no direct connection with the through shafts *D*. Each pair of rollers carries the load of two full pan pitches on both the carrying and the return run; they are idle only while the apron is passing over the sprockets.

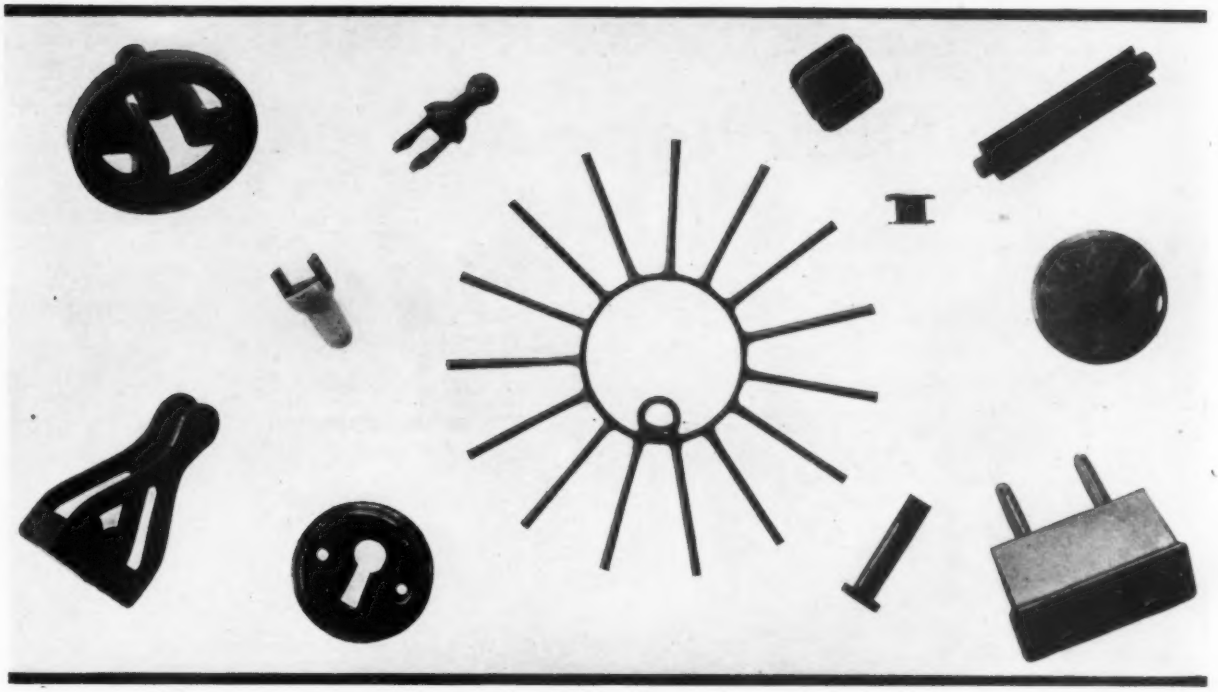
▸ Locomotive-Wheel Cushioning Device

A lateral wheel cushioning device is being applied to locomotives by American Locomotive Co. for the purpose of reducing wear on the rails and on wheel flanges when the locomotive is passing through a curve. This device is placed between the two driving boxes on each side of the axle and in line with the journal-bearing faces. Each unit consists of two end spring seats fastened to the shaft, and two compression springs separated by a shaft washer. Yokes are welded to the inside faces of the boxes and support the units. No outward pressure is exerted by the compression springs against the box while the locomotive is running on a tangent track, the boxes having free working clearances in the shoe and wedge jaws. When entering a curve, the wheel flange against the outer rail moves inward and carries with it the inside box, compressing the springs against the outside box.



To support the wheel cushioning device, yokes are welded to the inside faces of the bearing boxes. Two units are used per wheel set

Because of high dielectric strength, styrol plastics are particularly suited for radio parts. The material is also used for general molding, as a protective varnish, and as an adhesive



Styrol Plastics

facts and figures about a versatile molding material

After having passed through their period of development and small scale commercial production, the styrol plastics are now coming into more general use, particularly in the fields where excellent dielectric qualities are required. They are specially suited to high-frequency radio equipment, coils, panels and similar parts, as their insulating qualities excel those of any other material with the possible exception of quartz.

In its pure form, styrol is colorless and transparent, but can be colored by the addition of pigments. In appearance it resembles nitro-cellulose, but unlike it, the material is much less inflammable and is also highly resistant to moisture absorption. In its pure form it will not absorb any moisture, but the addition of pigments or other fillers usually causes a limited amount of water absorption.

The strength of the material will depend considerably on the fillers used and the process of manufacture. The transverse strength is given as ranging from 8,600 to 15,000 lb. per sq.in., and the tensile strength as ranging from 4,000 to 8,000 lb. per sq.in. Similarly, the impact strength will be affected by the fillers, but an average figure is 17 cm.-kg. per square cm.

Styrol plastics are subject to cold flow and for this reason, if used under pressure, such as may be exerted by clamping or fastening with screws, the molded parts might change their dimensions enough to result in loosening the screws or the piece. Plastic flow varies with both pressure and temperature, and under the normal pressures and temperatures met in ordinary service the material can be compounded so that there will not be trouble arising from cold flow. The material begins to soften at about 90 deg. C. This figure can also be varied from 20 to 25 deg. C. by the use of fillers.

Many grades of this material are produced for molding either by the injection process or by ordinary press methods. In Germany, the product is marketed under the trade name "Trolitul". The American manufacturer of this material is the Naugatuck Chemical Company which markets it under the trade name "Victron".

In addition to its normal use as a molding compound, styrol is also available in the form of a varnish, being used as a protective coating to resist water, alkalis, and acids. It is soluble in chloroform, carbon tetrachloride and similar hydrocarbons. This material has also been developed in the form of an adhesive and is finding use for cementing leather in order to eliminate the stitching operations. The cemented joint is also stronger than the stitched seam.

In addition to these particular applications, styrol is also being used for phonograph records, its advantages being that it eliminates much of the scratching noise, and the record can be made thin and flexible.

Temperature Calculations for Clutches and Brakes

A. C. RASMUSSEN
Mechanical Engineer, Indianapolis, Ind.

In this article the author analyzes the relation between the heat-dissipating and the friction areas and shows how the capacity of a brake or clutch can be increased by special provisions. Practical examples given in the article illustrate the use of the equations developed

When the faces of a clutch are brought in contact, the torque on the driven shaft and driving shaft, as determined by the friction at the engaging surfaces, is equal. It is evident that while bringing the speed of the driven shaft up to that of the driving shaft, the power delivered to the clutch will be greater than the power output on the driven shaft, these powers being measured by the torque common to both shafts and the respective shaft speeds. The difference between the power output and input is the energy wasted as heat at the friction surfaces.

On large machines, clutches that are used continuously often present more of a problem of heat disposal than of mechanical design. The temperature of the whole clutch structure increases until the rate of heat dissipation balances the rate of heat generation at the friction surfaces. If the temperature at which this balance takes place is excessive, the clutch facing will be destroyed.

Dissipation of heat occurs, first, to some extent by radiation, second, by conduction through contacting metallic parts, and, third, by convection into the surrounding air. Actually, the first and last are the only methods by which the clutch gets completely rid of the heat. Fortunately, the clutch rotates almost continuously and often at high speed, which is favorable to rapid heat dissipation. When air circulation is not restricted, the greatest amount of heat is taken away in this manner.

Free access of air is necessary, and should the side supporting stand present a rather solid wall along one side, large unobstructed openings should be provided under the friction drum so that as the heated air rises, cool air can flow in from underneath. Some drums, as shown in Fig. 4, have diagonal cross-channels under the flanges. As the drum revolves, air flows through these passages. This construction is highly effective and necessary in some cases.

The character of the heat dissipating surface has a considerable effect on the rate of heat loss. Rough unpainted surfaces have a higher rate of heat loss than bright machined surfaces. Black, and next in order dark colors, are better than light colored paints.

Air should be allowed to get to the friction surfaces, these being at the highest temperature and therefore lose heat most rapidly. Supports for the friction band should be arranged to lift the band entirely free from the drum when not engaged. Not only do dragging bands cause considerable power loss, and hence generation of heat, but clear lifting of the band also allows the escape of the hot gases from under the band to carry off considerable heat. These gases are formed by the gradual disintegration of the friction material through wear.

Expressed in ft.-lb., the energy absorbed by a brake, except for that lost by mechanical friction in the related moving elements of the machine is equal to the product of the weight and the total distance in feet through

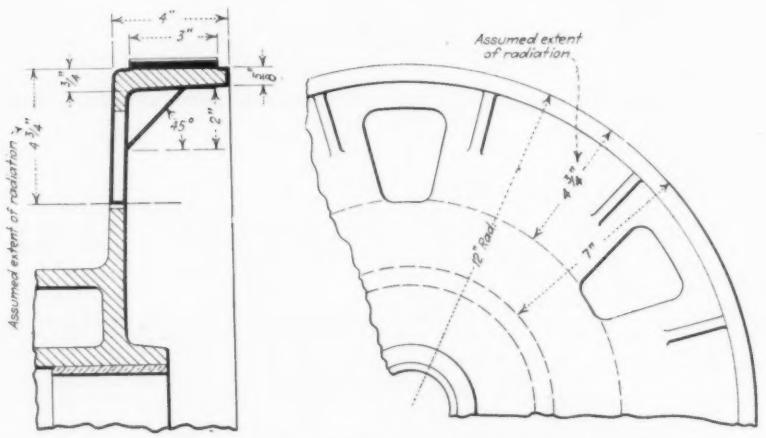


Fig. 1—The radiation area in this typical brake drum is considered as extending toward the center a distance as noted and indicated by the heavily shaded lines

which it is being lowered. Let W equal the weight in lb. and h the distance in ft. Then the energy absorbed, neglecting friction, is Wh ft.lb., or expressed in B.t.u.:

$$H = \frac{Wh}{778.3} \text{ B.t.u.} \quad (1)$$

(778.3 ft.-lb. = 1 B.t.u.)

Although some of this heat is lost almost immediately into the air, let it be assumed for the present that it all passes into the metal rim and the supporting flange of the friction drum. The rise in temperature of the rim is dependant upon the weight of the rim in lb. and the specific heat of the metal.

Let t_r = temperature rise
P = weight of rim, lb.
S = specific heat of the metal

$$t_r = \frac{H}{PS} \quad (2)$$

Substituting Equation (1) in Equation (2):

$$t_r = \frac{Wh}{778.3\ P\ S} \quad (3)$$

Neglecting concurrent loss of heat, this gives the rise in temperature of the brake rim through absorbing Wh ft.-lb. of energy.

The specific heat of the metals used for friction drums are 0.130 for cast iron and about 0.116 for steel.

The maximum permissible temperature considered good practice is 500 deg. F. for the best grades of asbestos friction lining used on a cast-iron or a steel drum. If the air temperature is 70 deg. F., then the permissible temperature rise will be 430 deg. F., that is, the difference.

Transposing Equation (2), the amount of energy H in B.t.u. required to raise the temperature of the rim t_r deg. F., will be:

$$H = P\ S\ t_r \quad (4)$$

It would be quite impossible to calculate accurately the time required for the brake rim to cool to air temperature because the laws on the rate of cooling are not well established. However by calculating the rate of heat loss from a given device at a given temperature, the rate of heat input required to maintain that temperature becomes known, the two being equal. From these figures, therefore, the allowable load in horsepower for any given temperature becomes known. For the maximum allowable temperature, the maximum corresponding horsepower load can be calculated.

With frequently used clutches and brakes, where long applications do not occur, it is less essential to determine the temperature reached by the brake rim from a single application than it is to calculate the area required to provide a rate of cooling greater than the rate of heat generation. This therefore will be the basis of the following analysis. Later the effect of single long applications on the rim temperature will be shown.

The horsepower capacity per square inch of a clutch or a brake has been designated as M. It was stated the numerical values for M given in the previous article applied to clutches and brakes used in excavating machinery of the shovel or reciprocating digger type.

This horsepower per square inch converted into units of heat will require the dissipation of 42.4 M B.t.u. per minute, a hp. being equal to 42.4 B.t.u. per minute. However a clutch or a brake is not used continuously, whereas the dissipation of the generated heat occurs continuously. The term "load factor" has been chosen to indicate the portion of the time that the clutch or brake is in continuous use. Representing load factor by q, then $q\ M = N$, the actual amount of horsepower per square inch being converted into heat. Therefore the actual amount of heat generated per minute per sq.in., H_g is:

$$H_g = 42.4\ q\ M \quad (5)$$

This amount of heat must be dissipated by radiation, convection, and by conduction. The rate of dissipation is a function of the temperature difference, the exposed radiation area, a combined coefficient covering radiation, convection and conduction per unit of exposed area, and a factor for this coefficient dependent upon the temperature difference.

Let
t_1 = temperature on friction drum surface.
t_o = temperature of surrounding air.
$t_1 - t_o$ = temperature difference.
A_r = area of radiating surface per sq.in. of friction surface in contact.
X = combined coefficient for radiation, convection and conduction expressed in terms of B.t.u. per min. per sq.in. of radiation surface per deg. F. temperature difference.
a = factor dependent upon temperature difference, since rate of heat loss is not directly in proportion to temperature difference but is greater at higher than at lower temperatures.

Let H_d represent in B.t.u. the rate of heat dissipation per minute for A_r square inches of radiating surface. Then:

$$H_d = (t_1 - t_o)\ \ A_r\ X\ a \quad (6)$$

This rate of heat dissipation must be equal to or greater than the rate of heat generation. Hence:

$$H_d \geqq H_g$$

$$(t_1 - t_o)\ \ A_r\ X\ a \geqq 42.4\ q\ M$$

$$A_r \geqq \frac{42.4\ q\ M}{(t_1 - t_o)\ \cdot X\ a} \quad (7)$$

The value for the rate of heat dissipation per sq.in. of radiating area $(t_1 - t_o)\ X\ a$ varies between 0.15 B.t.u. per sq.in. per min. for friction drum temperatures to be kept within 200 deg. F. temperature difference, to 0.36 B.t.u. per min. for the

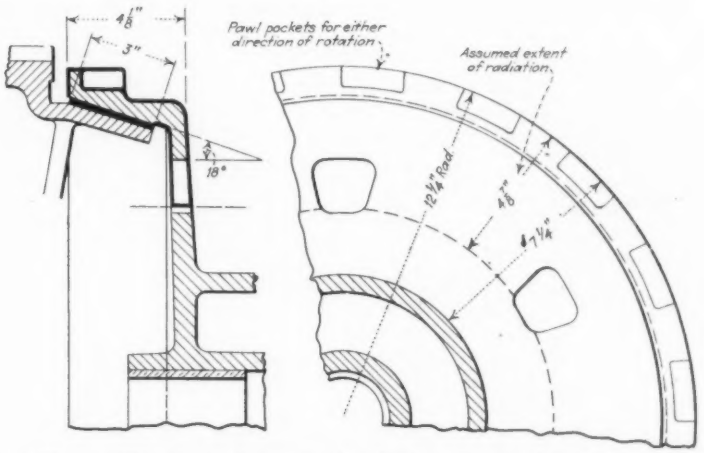


Fig. 2—The assumed extent of radiation area in this typical cone clutch is noted in the figure and also indicated by the heavily shaded lines

temperature difference to be within 400 deg. F.

In order to avoid unnecessary calculation, it is advantageous to express the rate of heat dissipation per sq.in. in units of hp. per sq.in. Representing this value as m,

$$m = \frac{(t_1 - t_o)\ X\ a}{42.4} \quad \text{hp. per sq.in. of radiating area} \quad (8)$$

The numerical values for $(t_1 - t_o)\ X\ a$ given above expressed in terms of m are 0.0035 and 0.0085 respectively.

Intermediate values are approximately as shown in the following table:

Temperature Difference Deg. F.	$(t_1 - t_o)\ X\ a$	m
100	0.06	0.0014
200	0.15	0.0035
300	0.25	0.0059
400	0.36	0.0085

Equation (7) therefore can be written

$$A_r \geqq \frac{q\ M}{m} \quad (9)$$

Values of q for excavating machinery of the shovel type will vary between 0.20 and 0.33.

Radiation surface area for a drum will include all of the surface of the rim not covered by the band and the solid part of the supporting web down to the center line of the holes that are often placed in the web for reducing the casting weight. However, if the holes are not excessive in size more of the web can be counted in. Interior surfaces placed closely adjacent to a solid web gear should not be figured as radiating surface unless air can circulate freely through the space.

Example: Given load factor $q = 0.25$, hp. per sq.in., $M = 0.25$ and dissipation factor $m = 0.0085$. Then

$$A_r \quad \frac{0.25 \times 0.25}{0.0085} \geqq 7.35 \text{ sq.in. per sq.in. of friction surface in contact.}$$

Certain types of machinery, particularly hoisting engines, material hoists, and derricks, will have a load factor different from that of shovels. It may be higher or lower but the principal difference will be that the duration of the application of the brake will be greater and the brake drum rim and adjacent parts will become quite heated. Also longer intervening periods will occur so that the rim can cool down quite a bit before the next application. In machinery used for this kind of service, the rim of the friction drum must be large enough to absorb considerable heat, as the rate of generation is greater than the rate of dissipation for the time that the brake is applied.

In designing brakes for machines such as hoisting engines, the assumption cannot be made, as is made for shovel-type excavators, that the service on the brake is approximately the same as the service on the clutch, inasmuch as the load factors will be different. Customarily the brakes are much larger than the clutches, especially on heavy duty hoists. No comparative data can be given here for the reason that this relation will differ according to the required service.

The horepower per square inch asbsorbed by the brake will have to be determined in a different manner. If W is the maximum load in lb. to be lowered, h the distance in feet and t' is the time in minutes, then the horsepower absorbed is

$$hp = \frac{Wh}{33000\ t'} \quad (10)$$

The brake drum rim on a hoist used for such service will be cold at the start. At the end of the first application the brake rim may be warm. During the rest period it will cool off but will not cool back to the original temperature. On account of the residual heat, the temperature at the end of the second application of the brake will be higher than at the end of the first application. Also the temperature to which the rim cools after the second rest period will not be as low as after the first rest period. With continued use, the high temperature will reach a maximum and if the period of operation is uniform and the load constant, the high temperature will be the same after each braking operation. Likewise the low temperature will be the same after each rest period. A certain mean temperature exists which would be the temperature reached by brake drum rim if the braking operation was continuous and at a rate equal to the average energy absorption. In using the formulas already given this mean temperature has been decided upon in working up the design and in these formulas the energy absorption has been considered as being at an average uniform rate. For practical purposes it can be assumed that the heat loss is uniform over the temperature range between high temperature and low temperature. The high temperature would therefore be as much above the mean temperature as the low temperature would be below the mean temperature and the mean temperature would be the average temperature.

Equation (3) can be modified to show the temperature variation between high and low temperature. Simultaneously with the absorption of heat by the rim at a load factor of unity there is also a loss of heat at the rate m hp. per square inch of radiating surface. The difference determines the increase of rim temperature for the period of the application of the brake.

If t' is the time in minutes or frac-

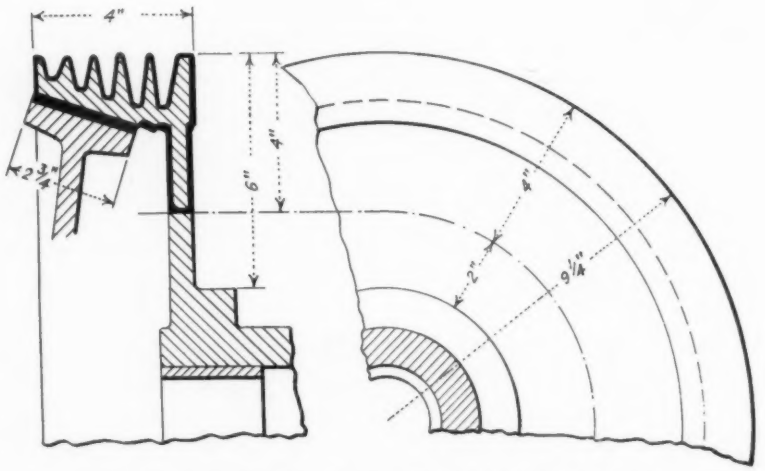


Fig. 3—Radiating fins, as applied to this cone clutch, are sometimes added to increase the rate of heat dissipation

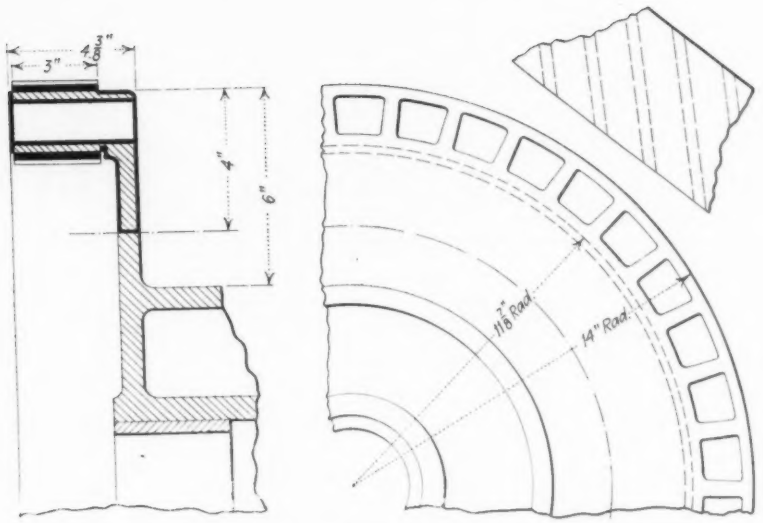


Fig. 4—Holes through the drum and between the friction surfaces of the internal band clutch and external band brake, add considerable to the heat-dissipating capacity

tion of a minute required for the braking operation, then the heat lost for this time is H'.

Then

$$H' = (t_t - t_a) \quad A_d X \, a \, t' \qquad (11)$$

(A_d = total radiating area, sq.in.)

Since

$$m = \frac{(t_t - t_a) \; X \; a}{42.4}$$

Therefore

$$H' = 42.4 \; m \; A_d \; t' \qquad (12)$$

The heat generated is given by Equation (3)

$$H = \frac{Wh}{778.3}$$

The difference between H and H' is the net heat H_n added to the brake rim during the braking operation.

$$H_n = \frac{Wh}{778.3} - 42.4 \; m \; A_d \; t' \qquad (13)$$

The temperature rise t_r is given by Equation (2) in which H_n is substituted for H.

$$t_r = \frac{H_n}{P \, S} \qquad (14)$$

$$= \frac{Wh - 33{,}000 \; m \; A_d \; t'}{778.3 \; P \, S} \qquad (15)$$

Example: A certain hoisting engine is used for a purpose requiring the lowering of a 7,500-lb. load. The duty cycle takes 1.0 min. for hoisting, 0.5 for lowering the load and 0.3 min. for loading and unloading. The hoist height is 150 ft. The average temperature rise to be permitted is 400 deg. F. It is desired to know if the brakes are ample in size.

Drum dia. d = 30 in.
Width of band b = 3 in.
Extent of warp k = 0.85
Therefore area of brake surface A = 240 sq.in
Hoist period = 1.0 min.
Lowering period = 0.5 min.
Loading and unloading = 0.3 min.
Duty cycle = 1.8 min.

The rate at which energy is absorbed in lowering 7,500 lb. a distance of 150 ft. in 0.5 minute is equivalent to 68 hp. (Equation 10). Since the entire duty cycle is 1.8 minutes of which 0.5 minute is taken for lowering the load, therefore the load factor q is $0.5 \div 1.8 = 0.28$. Since the energy absorption is 68 hp. on 240 sq.in. of brake area, then M is 0.283. Therefore

$$A_r = \frac{q \; M}{m}$$

$$= \frac{0.28 \times 0.283}{0.0085}$$

= 9.3 sq.in. of radiating area per sq.in. of brake area.

The required radiating area therefore is $9.3 \times 240 = 2{,}230$ sq.in. Inspection of the drum shows that this area can be counted on for radiation and therefore the temperature rise should be within 400 deg. F. The drum is of cast-iron and has a calculated rim weight of about 250 lb. The temperature variation is then calculated as follows:

$$t_r = \frac{Wh - 33{,}000 \; m \; A_d \; t'}{778.3 \; P \, S}$$

$$= \frac{7500 \times 150 - 33.000 \times 0.0085 \times 2230 \times 0.5}{778.3 \times 250 \times 0.130}$$

$$= \frac{1{,}125{,}000 - 312{,}760}{25{,}300}$$

= 32 deg. F.

The drum temperature rise should vary between 384 deg. F. and 416 deg. F. above air temperature, for an average temperature rise of 400 deg. F.

Temperature calculations are very approximate at the best and many factors are involved. In the design of a new clutch or brake having no direct relation to a satisfactory one already in service, considerable difficulty often is experienced because of lack of data which is directly applicable.

One is often confronted with the statement that each clutch or brake problem is different from others and has to be analyzed separately. This is true, nevertheless the analysis would be easier if sufficient data of a general nature were available.

As with all technical matters one should be guided by actual installations, and the foregoing article is offered as a method for making proper comparisons.

Pearl Essence

Though discovered by Jacquin over three hundred years ago, pearl essence found its almost sole commercial outlet in the manufacture of artificial pearl beads until its present incorporation into lacquer finishes by several automobile manufacturers and at least one builder of airplanes.

Until 1914, pearl essence was a European monopoly, being produced from the scales of a small fish of the minnow family not found in American waters. Now it is produced in New England, Virginia and New York.

The blade structure of the essence crystals is essential to the luster; one gram of the crystals has an aggregated surface of about 12,575 sq.cm.—somewhat more than a square yard—and contains about 312,500,000 individual crystals. Their specific gravity is about 1.6.

The crystals show their maximum luster when oriented parallel to each other. Thus the manner of application of lacquers or other materials containing pearl essence is important in obtaining the maximum desirable optical effect.

Clamping Shoes

F. A. FIRNHABER
Machine Designer
Landis Machine Company

Many devices, ranging from expensive contrivances down to a simple set-screw, can be used for retaining two machine members in a fixed position. The inexpensive but highly efficient clamping plugs used for this purpose do not seem to enjoy the popularity they deserve. A number of possible constructions are shown

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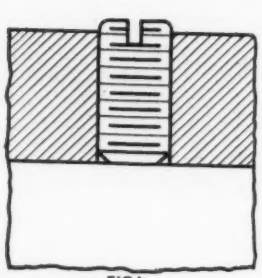


FIG.1

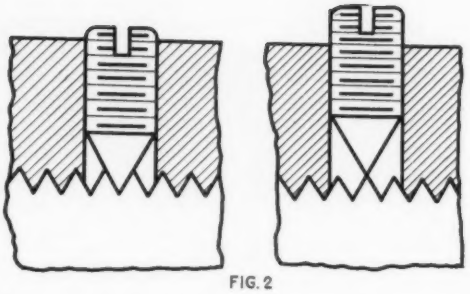


FIG. 2

Fig. 1—The older methods, as shown here and in the following figures, mar the shaft to the extent that disassembling might be impossible. At the best, the smooth surfaces of the hole are scored and ruined

Fig. 2—The 60-deg. point does not always line up with the bottom of the thread. As shown to the right, the metal at the top of the thread is displaced, shaving the threads and making it hard to turn the nut

Fig. 3—A flat filed or milled on the shaft is an improvement. But the cup point of the screw bites into the flat, and once a ring is made into the flat it is hard to get clear of it when the held member must be moved to either side a slight amount

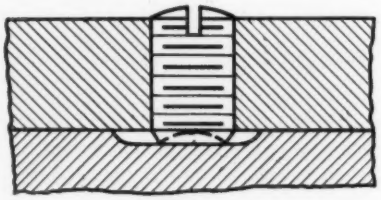


FIG.3

Fig. 4—A further improvement is a brass plug making a loose fit with the inside diameter of the threaded hole

Fig. 5—A variation of the preceding construction is obtained by making the plug a press fit in the screw

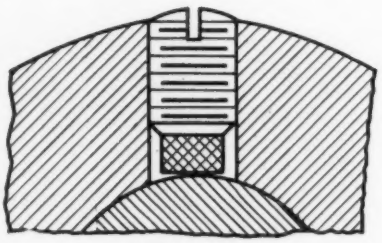


FIG.4

Fig. 6—Here the side contacting with the shaft makes a full fit, accomplished by inserting a reamer into the hub bore and constantly feeding the clamping screw while the reamer is turning

Fig. 7—This is similar to the construction shown in Fig. 6, a tap being used instead of a reamer

FIG.5

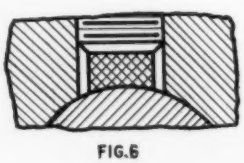


FIG.6

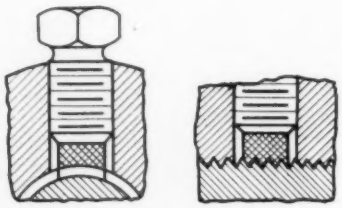


FIG.7

Fig. 8—When a longer clamping surface is desired, a slot similar to a keyway is cut into the retaining member

Fig. 9—This construction facilitates the removal of the plug but can be used only when the diameter of the clamping screw is large enough. Freedom of the internal fillister head screw permits the plug to assume its natural position against the shaft

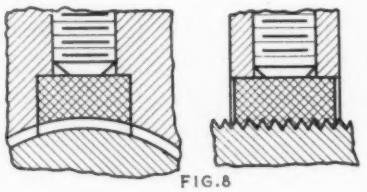


FIG.8

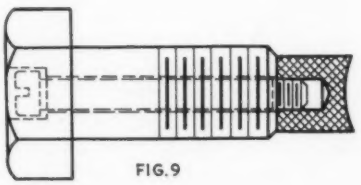


FIG.9

and Plugs

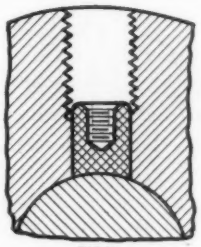


FIG.10

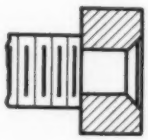


FIG.11

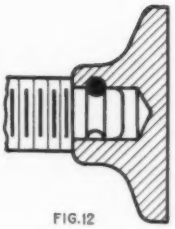


FIG.12

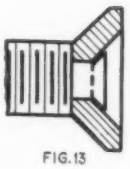


FIG.13

Fig. 10—This is another method for removing a plug. By first removing the clamping screw and then inserting a small screw to fit the tapped hole, one can fish out the plug

Figs. 11-12-13—In these modifications of the clamping plug, the shoe is assembled after the clamping screw is screwed through the hole. In Figs. 11 and 13 the shoe is retained by spinning or riveting, while in Fig. 12 a pin through the hub of the shoe engages the circular half-round groove near the end of the screw. In each case the shoe bears against the shoulder of the screw

Fig. 14—Here the plug is in the form of a rod which allows the use of a short setscrew. This saves tapping a long hole and using a long screw

Fig. 15—A lock washer under the hollow headless screw locks both the screw and plug in place

Fig. 16—This is another adaptation of the methods used in Figs. 11-12-13. A ball end is pinned fast in the retaining screw which acts like a swivel for the clamping shoe, the latter being held in place by a small fillister head screw in an oversize hole. The swiveling permits the shoe to accommodate itself to rough or uneven surfaces

Fig. 17—Here the shoe clamps the ring about the shaft. It is made key form, that is, a slot is cut in the external member to accommodate the shoe. The V in the shoe should be 90 deg.

Fig. 18—The round pointed screw allows the plug to swivel 6 to 8 deg. The pin is for locating work in a level position, a number of them being used for this purpose. The flat is milled 6 to 8 deg. from the vertical, the feature being that the plug prevents lowering when weight is applied

Fig. 19—In this modified construction, the dog point setscrew retains the key after the screw is loosened, the dog point fitting in the oversize hole in the key. This, of course, requires a key somewhat wider than the diameter of the dog point of the screw

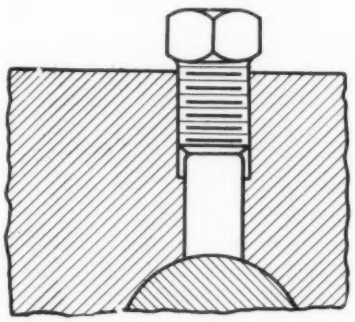


FIG.14

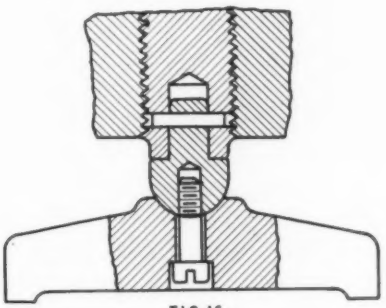


FIG.16

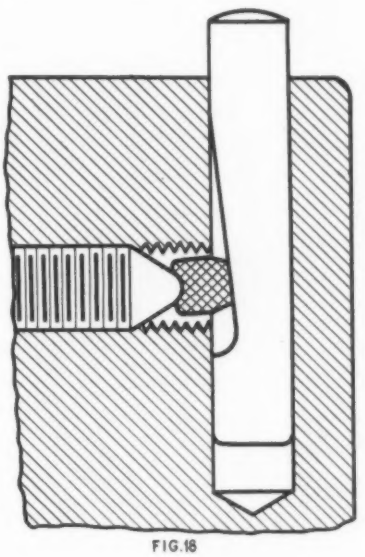


FIG.18

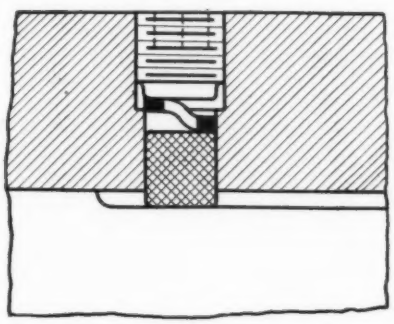


FIG.15

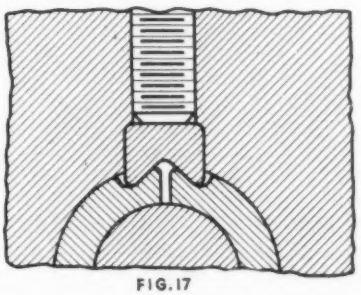


FIG.17

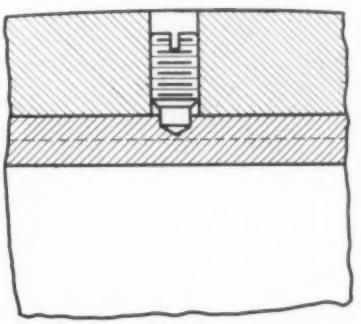


FIG.19

EDITORIALS

KENNETH H. CONDIT
Editor

What Should Be the Basis?

What should be the basis of cooperation between the manufacturer of a new material or device and the engineer who might possibly incorporate it in his design? Only too often it seems to the vendor that the engineer stubbornly and wilfully refuses to give his serious consideration, whereas to the engineer it frequently appears that the vendor is attempting to sell him a "cat-in-a-bag."

To be on a cooperative working basis, each must consider the other's problems and responsibility. The engineer has a specific obligation to his employer to adopt the commercially best material available. He knows that only in this way can he develop an outstanding product that will command a wide market. It is for this reason that every engineer worthy of the name is at all times anxious to learn of the possibilities offered by new materials and devices.

On the other hand, no responsibile materials or parts manufacturer suggests the use of his product in a service for which he believes it unsuitable. He knows that just one failure will condemn it in the eyes of many for a long time to come. It should be evident to any vendor that he is as much interested as the designer.

It is true, on the other hand, that there are some sales engineers who resort to "high pressure" methods in an attempt to secure the adoption of their material or device. And there are designing engineers who stubbornly refuse to consider the possible use of a new material, mistakingly priding themselves on their conservatism, which in truth is only retrogression. But these types of vendors and engineers are in such a minority that they need not be given serious thought.

Progress requires team work; herein lies the solution to the problem of introducing something new. The manufacturer of the material or device must recognize the engineer's problem. He must really appreciate the fact that in the final analysis engineering design is largely a matter of judgment based on experience. Without an intimate knowledge of the material or device there cannot be intelligent judgment. Therefore, the first problem of the vendor is to make the engineer familiar with the material. Not only must the engineer be given all available data, but the manufacturer must also establish the behavior of the material under the specific conditions to be met and investigate possible manufacturing difficulties. In some instances he might even build samples and test them, in order to establish a given fact.

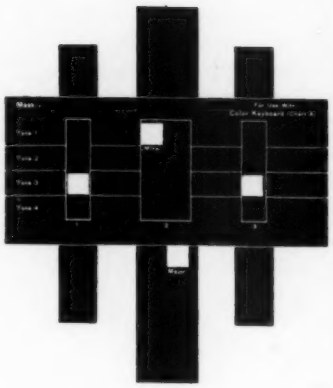
As to the engineer, he will find it profitable to take the manufacturer fully into his confidence and explain the design in all its detail. Much depends on how thoroughly he points out the conditions to be met and makes known the history of the product. The engineer gains much by accepting from the manufacturer cooperation in the development of the design incorporating the new material or device. Of course, this does not relieve the engineer of his share of the risk and responsibility. Those are items he cannot pass on to others. Good team work still wins any game; it is never more necessary than in the engineering problem of applying a new material or a new device.

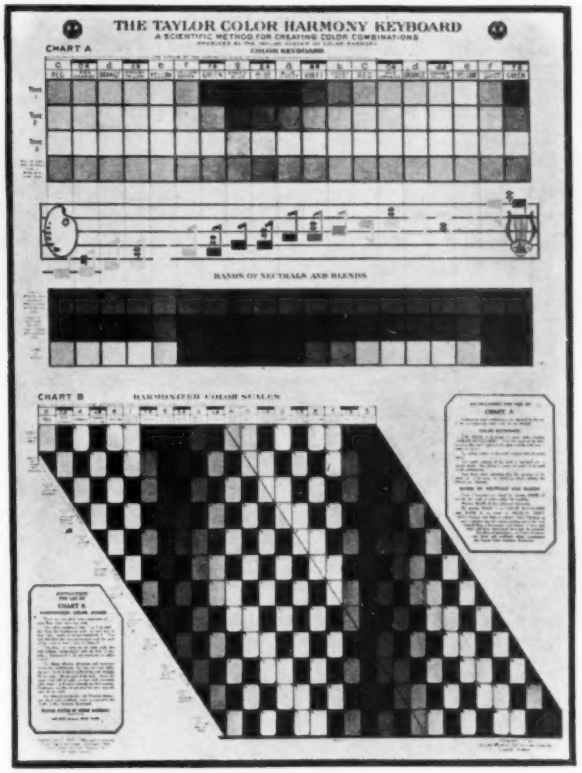
Victims of Habit

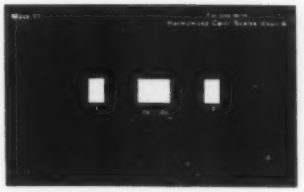
One of the greatest impediments to progress is strict adherence to "standard practice," this being usually nothing more than doing a thing in a certain habitual way that experience up to that time has shown to be effective and economical.

But the world does not stand still. Knowledge increases, bringing with it new light on old problems. Existing ideas will then be thrown into the discard. New materials and improved old materials will alter conceptions of "the best material available," both from the economic standpoint and that of technical requirements. As time goes on, even operating conditions will be changed, demanding new designs.

Engineers who are sticklers for "standard practice" are merely victims of a vicious habit.







Basic chart of the Taylor System of Color Harmony. Given a color of a certain chroma, blend or intensity, one places an opening of any one of three different masks over the color to determine three different colors that will harmonize with the original unfailingly. For instruction purposes the colors have been harmonized in terms of musical notation

Color by Trial and Jury

HAZEL H. ADLER
Taylor System, Inc.

Mrs. Adler directs the work of Taylor System, Inc. Her organization has been retained as consultant on color design and product development by such varied and important clients as: Austin Manufacturing Company; Ford Motor Company of Canada; B. F. Goodrich Company; Kohler Company; Rome Metal Bed Company; Sears Roebuck & Company; Vollrath Company; Western Clock Company; Youngstown Pressed Steel Company

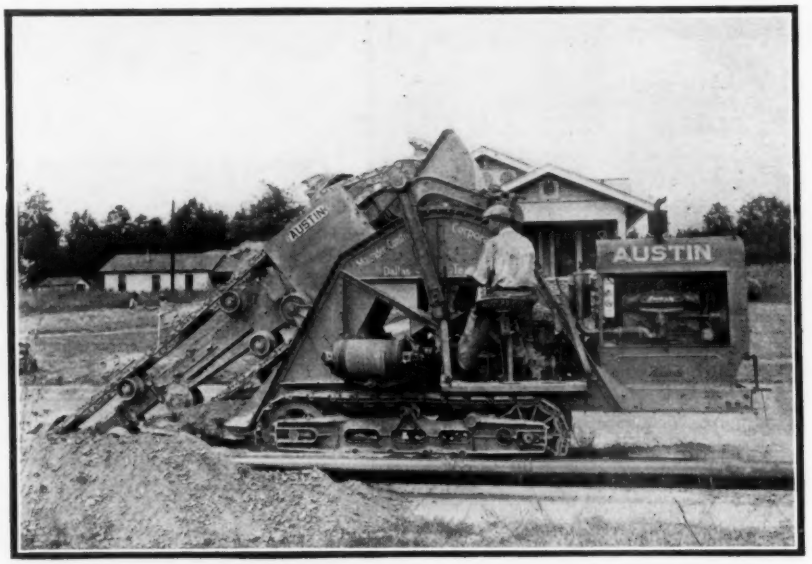
When a product is built by hand, one by one, the craftsman takes no great risk in selecting a color at random or in leaving color entirely up to the customer. But when any large degree of mass production is involved, where products must be manufactured for stock in advance of actual sales, the selection of color becomes a matter of vital sales and financial import. The manufacturer must know in advance, not guess, that the colors of his line are right, that they will sell—or his balance sheet is bound to be adversely affected.

It has been our good fortune—and, we think, that of our clients—to have been retained as color and design consultants by several score representative corporations. To illustrate what we mean by selecting "Color by Trial and Jury" we will cite two recent undertakings.

In the first the problem was to determine a color combination for a prominent road machinery manufacturer, a combination that would both trade-mark his products and cause them to blend or harmonize with the locations on which the various machines would work. Not least among the specifications was that of rendering the machines attractive to buyers. An idea of the difficulties to be overcome is indicated by the fact that the line included a trench digger to excavate a cut 16 in. wide and 5 ft. deep, and another to excavate 130 in. wide and 15 to 26 ft. deep.

Since the products were to be sold to men and would have to stand rough usage in service, it was obvious that we should shy away from pastel and other "dainty" colors. We gathered together the various road and landscape colorations with which the machinery would have to blend or harmonize. With the Taylor System chart of color harmony we determined colors that would harmonize unfailingly therewith. We asked the manufacturer to finish various machines in colors of our preliminary selection and to place them on trial in various locations. We gathered and charted statistics on the reactions of different contractors, road builders and house owners; in other words we placed the experimental colors on trial.

That completed, we reduced the selection to a few color combinations and requested the manufacturer to assist us in appointing a representative jury. To shorten a story that is running too long for the available space, the final selection was a rich,



The color scheme of this Austin Model 90 trench digger was determined by trial and jury under the direction of the author of this article. Surprising as it may seem, a rich blue with lettering and striping in terra cotta was found to blend best with the foliage and ground colors of the average landscape. Since they also carry consumer appeal the combination was adopted as standard for road machinery by the manufacturer, including the giant Model 500 which appears on the front cover

wear- and weather-resisting blue with striping and lettering in a terra cotta shade.

Our other undertaking was something else again. When the sales manager of an outstanding manufacturer of enameled iron and vitreous china plumbing fixtures came to us he was in a fair way to losing twenty pounds along with his market. Fortunately he kept nothing back. He told us how he had simply thrust a handful of samples of pink chiffon, green voile and possibly a bit of heliotrope jersey into the hands of the chief engineer.

"These are the popular colors in New York this season," he said.

The chief engineer passed them along to the factory manager. Out in due time came a line of colored fixtures. Out went advertising and salesmen. And up went sales.

Up stayed sales, for a matter of months. Color, though old as the world itself, was a new thing in standard, factory-made products. And then for no apparent reason and despite every sort of selling pressure, sales collapsed.

We had to tell him that his story was almost typical. Just as gently as possible we told him that the real reason his sales of colored products skyrocketed originally was that there is a class of buyer in this country who will buy anything new. Good taste has nothing to do with such sales; newness is everything. But fortunately or unfortunately the real buyers of this country have taste. Color must be right to sell consistently year in and year out. And the surest way of getting them right in advance is by trial and jury.

For the manufacturer represented by this sales manager we could take it for granted that the products were right in design and manufacture. Our immediate problem was to select one color that would harmonize with the greatest possible range of interior colors to be found in American homes. Rather than select it in the abstract, we sought an "architectural color," one that had proved pleasing to a vast mass of differing temperaments over a long period of years. By diligent trial and research we decided that a creamy "sunburnt clay" color was as nearly basic as anything to be found. From biblical times to the present it has been a universal favorite; it has lived and endured. It is clean, crisp, sanitary looking; it is "neutral" and thus will harmonize with almost anything. In homes and museums we sought and found samples of this sunburnt clay color.

On April 6 we shipped the manufacturer a Gestrickland pottery jug with instructions to duplicate the cream tone of its background in both vitreous china and enameled iron. We asked for a small color sample and a sample large enough to test the effect of the color on a large surface. We also shipped a piece of cream-colored tile as an alternate. May 3, we received the samples and tested them. The vitreous match was fair. In sunlight the color was weak; in shadow, it seemed to turn gray. In normal daylight it was good; it faded out in artificial light. Generally the sample seemed to lack pigment body. The enameled iron match was good. The color was good in sunlight, but shadow emphasized its yellowish cast. Under normal light, the color seemed to bleach; under artificial light it took on a purplish cast. It seemed that more "umber" was needed in the pigment.

May 7, we returned the samples to the manufacturers with our comments and included in the shipment a pottery book-end and an antique Italian casket, borrowed from the Thompson Collection, for further color comparisons. This time we suggested that full size samples be made up and requested that a color conference or jury be called. May 8, we wrote in part as follows:

> In order to prove certain basic principles which must form a basis of judgment in passing on new colors for your line, we are going to make a demonstration to you for which we will need a space where we can subject the colors to various lights. . . We are asking you to prepare as follows:
>
> 1. Select a space in the warehouse where we can have strong sunlight either in the morning or in the afternoon.
> 2. Allow sufficient space so that the colors may be viewed at a distance of from 15 to 20 feet.
> 3. Have available some screens or partitions so that we may cut off the sunlight and allow the viewing of these colors in the shadow.
> 4. As it will be necessary for us to subject the color samples to artificial light as well as daylight, we shall need to have artificial light available with two kinds of bulbs—the regulation yellow light and a blue light or daylight bulb.
> 5. Have an easily movable representative article or large part in all the colors you are making at present available.
> 6. Have all new color experiments and panels readily available.
> 7. Have available also your trials either in enameled iron or vitreous china which you have made so far in attempting to carry out our experiments. We would like to have all of the trials even those that have been rejected by you or by us in our previous conference.

In all, six booths were set up in the warehouse to test for effects under sunny exposure, shaded exposure,

normal (yellow) artificial light, blue-white artificial light. We directed the walls of each of the booths to be painted in accordance with samples submitted, and supplied textile hangings to test for harmony of effects with contrasting colors. We insisted that the jury consist of representatives from both the production and sales departments and that it must include at least three women.

May 21 we completed the test with the following results: 95 per cent of the jury approved of the color; under sunny exposure, 70 per cent approved; under shadow, 65 per cent; under yellow artificial light, 60; under blue-white, 75 per cent. For harmony with textile colors, 100 per cent approved of the combination of our shade of cream or sun-burnt clay with textile hangings in green, blue, red or black; 85 per cent liked it combined with orchid; 70 per cent with pink; 65 with yellow and 40 with white. The jury decided that our color through its reflective quality seemed to improve in rooms with green, blue, orchid or white walls, but that pink or yellow walls detracted from its appearance. Since pink and yellow are not prevailing colors for wall decoration, the jury recommended the approval of our particular shade of "sunburnt clay," and the manufacturer adopted it. Another color was launched on a color-loving public, and the ascending sales curve justified every moment of preparation and trial. Using almost identical methods we have since developed several additional colors and certain new products for this manufacturer.

Although these two examples of selecting color by trial and jury may seem to be outside the scope of the average engineering department, it should be clear that the same principles and methods may be applied to almost any similar problem. Since the customer is the final judge of any product the manufacturer must know with reasonable assurance in advance how his products are going to be accepted and bought.

V-Belt Life, Overload and Pulley Diameter

Discussion

C. A. NORMAN

Professor of Machine Design, Ohio State University

In view of the fact that the V-belt is a somewhat new product, not yet quite standardized in make-up and use, it is imperative that in articles about it particular pains should be taken to avoid creating misconceptions about its properties and mode of application. The writer's attention has been called to the fact that in his article in June *Product Engineering* a few statements need modification or amplification if wrong interpretations are to be avoided.

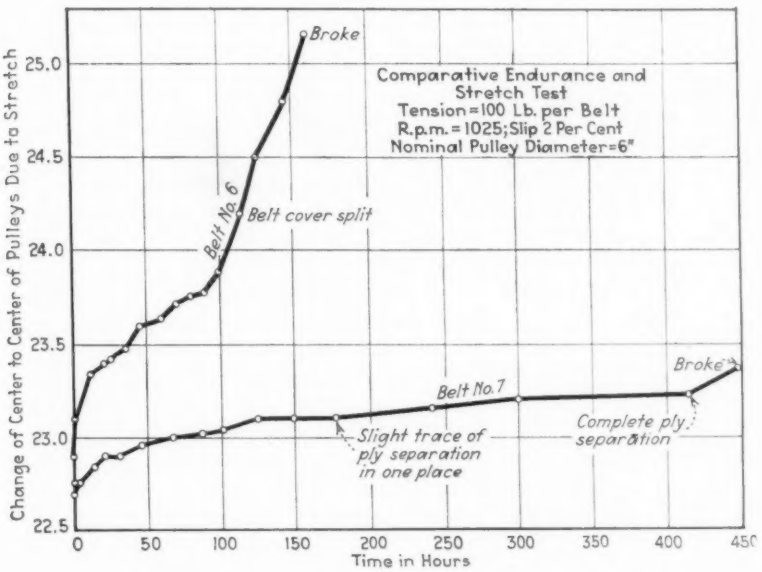


Fig. 1—Endurance and stretch tests of two V-belts

The first refers to the advice to use in designs the largest pulley diameter demanded to insure reasonable life with any V-belt readily available in the market. It should be understood that when economy of material, or lack of space, or any other consideration makes it desirable to use pulleys smaller than those required, for the least flexible and least durable types of belts, it should be kept in mind that there are readily available belts which make this possible. Thus in Fig. 1 there are plotted the endurance test records for two belts on the writer's type of testing machine. It will be seen that one has a life almost three times as long as the other and a very much smaller stress. The difference is so striking that there would seem to be little excuse for using the poorer belt at all, or redesigning for it, unless a very considerable saving in first cost can thereby be effected. The longer life and the less need for adjustment with the better belt may mean a money saving in the long run, even though its first cost is higher.

The second statement that may need amplification is the one regarding the possibility of using beginning failure of the wrapping as a criterion for the answer to the useful life of the belt. This statement, of course, refers only to the type of belt tested. In this type of belt the cords are arranged somewhat as a central core within a series of several wrappings, these latter forming an important part of the section. Little or no attempt is made to arrange the cords in a flat zone or ribbon at or near the neutral axis of the belt with a yielding tension member above and a yielding compression member below so as to avoid unequal stretching of the cords, internal wear and disarrangement of the parts generally. In the latter type of belts, i.e., in belts with parts so arranged, no wrapping may be used in the construction at all, or if it is used, it may form such an unimportant and subordinate part of the section that the belt may run for a long time after the wrapping has worn through.

The better belt in Fig. 1 is representative of this type. It manifestly would be absurd with belts of this type to regard beginning failure of the wrappings as the end of the useful life of the belt.

Motors and Their Controls

II. Direct Current Apparatus

Magnetic starters, remote control push button stations, automatic starters and preset speed regulators are discussed in this second article of the series

▲

Allen-Bradley Company

Automatic d.c. starter mounted on the base of the machine. Starting and stopping is controlled by the foot-operated lever

Manually operated drum reversing switches with separately mounted starting resistors for small d.c. motors up to 10 hp., and drum controllers for machine tools incorporating adjustable speeds, were described in the first article of this series, appearing in the June number of *Product Engineering*.

General-service reversing drum switches are also made for the larger sizes of d.c. motors for cranes, trolleys, lorry cars, bending rolls, and similar applications where reversing service is required and manual control is desired. On crane hoists, where a load brake is provided, standard reversing drum switches with preset contact permit series or shunt limit switch protection in one direction, that is to limit the travel in one direction.

Series limit switch protection refers to the use of a limit switch arranged to handle the full load current of the motor and to disconnect it from the line directly through its own contacts. In the case of shunt limit switch protection, the limit switch is arranged to handle only the pilot circuits that actuate a separately mounted contactor.

These drum switches may also be used with series or shunt magnet brakes and protective panels. Separately mounted resistors must be provided. Further modifications of this design of drum switch and accessories pertaining to it are:

(1) Shunt limit switch in both directions in order to limit the travel of the crane or device;

(2) A drift point provided on the drum control which allows drifting to either side of the "off" position;

(3) An armature shunt point in both directions. This is a resistance shunted across the armature in order to obtain a rapid slowdown, being in effect a dynamic braking. The control points that control the armature shunt are, of course, located in the drum switch while the resistors are separately mounted;

(4) Series or shunt wound magnetic brakes are sometimes incorporated in order to obtain sudden stopping. Here again the drum switch provides a contact for energizing the brake coil when the drum switch is moved from the "off" position. The energizing of this coil releases the brake;

(5) The operating head of the drum switch may be made to suit conditions. That is, the operating handle can be placed either horizontally or vertically. Sometimes a rope wheel, with or without a spring return, is used in place of a handle. A rope wrapped around the wheel and conducted to a distant control stand may be used for operating the drum switch manually. Another method is a geared right angle drive from the drum switch to the control stand;

(6) These drum switches may incorporate contacts for reversing, dynamic braking and dynamic braking when lowering a hoist operated by a series wound motor so that under heavy load the rate of drop will be retarded whereas under the lightest load the motor will drive the load down.

When the operation of a machine involves a number of motors, or when a number of motors are to be operated from a single control point, possibly located as a distance from the motors, remote control by push-button operation is usually installed. This type of control, which is somewhat more expensive than drum

switches, greatly simplifies the control of the motors. It permits greater flexibility in the arrangement of the controls, thereby making possible a neat and compact arrangement, simple and foolproof from an operating standpoint.

In the remote control push-button operation, the push-button is primarily nothing more than a simple switch controlling a pilot circuit. This pilot circuit in turn operates some form or other of magnetic starter. The simplest form of magnetic starter is a full voltage starting switch without the interposition of resistance. This type of starter is also termed across-the-line starter. It is applicable for direct-current motors, but only to the series or compound types, since the shunt motor is not suitable for across-the-line starting. The fundamental difference between these magnetic starters and an ordinary knife switch is that they provide a greater degree of protection to the motor. Furthermore, their quick action gives a high starting torque. Overload protection is provided with these starters by means of a thermal or magnetic relay.

This simple form of magnetic line starter for compound or series d.c. motors can be used for either reversing or non-reversing service for motors up to about 3 hp. at 230 volts.

Most safety codes require that a disconnecting switch be placed between the starter and the power line so that by opening the disconnecting switch the starting box will be dead, a precaution that should be taken when the starting box is to be opened for inspection, repairs or adjustments. This disconnecting switch is sometimes applied as a unit separate from the starting switch cabinet but most manufacturers of starters offer the alternate construction of having the safety disconnect switch built-in.

Remote control pushbuttons, or pushbutton master stations, are available in many styles and types. The most common are the two-button and the three-button combinations, the former being a simple start and stop control, the latter being for forward, reverse and stop. Another style of these control stations is the lever-operated unit which is finding considerable application on oil burners, electric refrigerators, and similar controls. These lever switches are also available for use in conjunction with the larger pushbutton stations, in which the third button of a three-button station is omitted and a lever switch is substituted. This gives the combination of two pushbuttons and one lever switch.

These remote control stations are also equipped with safety locking bars that make it possible to lock the switch so that it cannot be operated by unauthorized persons. Another type of magnetic starter similar to the one described above incorporates a definite time-limit acceleration. The acceleration is controlled by an adjustable clock escapement relay or a dashpot arrangement. An adjustment predetermines the elapsed time for cutting out the successive resistance steps, the starting resistors being incorporated in the cabinet. When starting, the resistors are in series with the armature and are progressively cut out by the clock escapement or dashpot controlled accelerating switch. The accelerating period of the starter is adjustable over a range to meet the requirements of the size of the motor. Normally, the accelerating period is from 5 to 10 seconds, but is adjustable over a range of about 2 to 15 seconds, and can be used for motors up to 10 hp., 230 volts. Their application is however also limited by the accelerating period and frequency of starting required, and these two factors will in some instances dictate a particular design of this type of starter.

With the starting resistors incorporated in the compartment of the cabinet, these time limit automatic starters are undoubtedly the most compact type of resistance starter available. They can be used for non-reversing only, but also incorporate overload and low-voltage protection. Overload protection is usually obtained by a thermal relay. The start and stop pushbuttons can be mounted in the cover, or a remote control push-button can be used. One type is with

Allen-Bradley Company

Start and stop push button control on vertical drill. Starting switch is mounted on the back of the drill frame

a two-way lever switch in the cover of the box. This switch has three positions. In the "off" position the pilot control is disconnected. With the lever in the automatic position the starter is under the control of the pilot circuit which in turn may be controlled by a remote station or some type of automatic switch. In the third position the pilot control is short-circuited and the starter remains closed as long as the lever is in this position.

Further modification of this starting box permits dynamic braking and full field starting. Of course, this latter also calls for consideration of the design of the motor as not all motors are designed to permit other than full field starting.

Mechanically, one of the great advantages of this type of starter is that a pushbutton or any form of master switch can be used, and located at the most convenient point. The form of master switch may be a float switch, a temperature control switch, pressure control switch or similar device. As in all of these types of switches, the disconnecting safety switch can be built-in with the cabinet or separately mounted.

In another type of automatic d.c. starter, the counter emf. controls the acceleration. At the start, the line contactor is closed and all of the accelerating contactors are open, but as the counter emf. generated in the armature of the motor builds up, the successive relays close. This starter is, of course, more expensive, but is available in sizes up to approximately 200 hp. at 230 volts. These starters incorporate inverse time limit overload protection and low-voltage protection, and have all the flexibility of the other types of magnetic starter in that they can be used with any convenient type of master switch.

A modification of the above described counter emf. control is that wherein the intensity of the armature current controls the acceleration. In this type, the closing of each successive accelerating contactor takes place when the current through the armature drops off to a predetermined value.

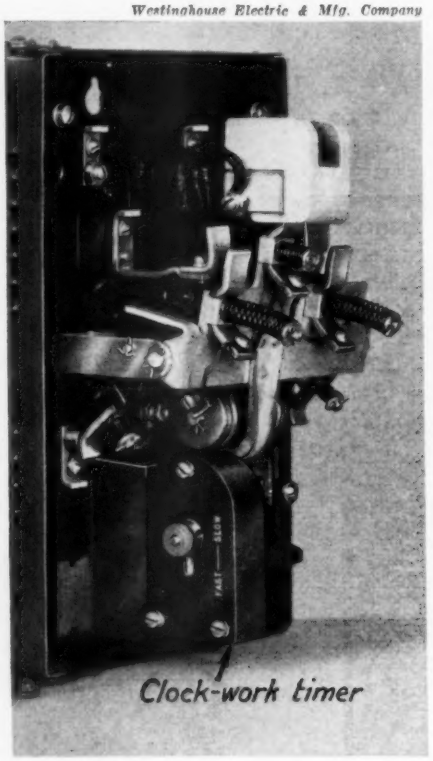
A further refinement of this last type of starter is the reversing magnetic starter for constant and adjustable speed, allowing a speed variation range of 2 to 1. This type of starter is fundamentally the same in construction as that described above except that it also provides for dynamic braking in the "off" position, thermal overload protection, and can be used for reversing service.

In all of these magnetic starters, the starting resistors are mounted in the rear of the box for motors up to 60 hp., 230 volts. On account of the large size of the resistors required for the greater horsepowers, the resistors must be mounted separately.

General-purpose motors driving machine tools usually use a type of starter that has a separately mounted field rheostat which permits the adjustment of the speed. These motors are specially designed when speed regulation is within a range of 2 to 1, so that they can be started with a weakened field, thereby making unnecessary the expensive full-field relay incorporated in order to insure a full field at the start.

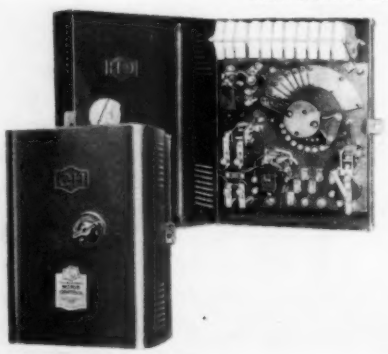
Definite time-limit acceleration magnetic starter controlled by an adjustable clock-escapement relay

Westinghouse Electric & Mfg. Company



Non-reversing automatic speed regulator of counter emf. type for motors up to 3 hp. Knob on the front is for setting to the predetermined speed. Resistor is mounted above the panel

Cutler-Hammer, Inc.

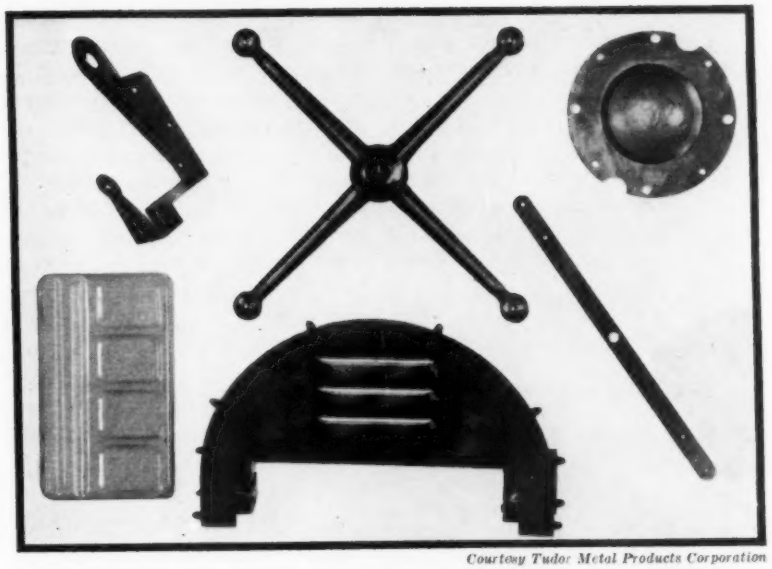


In these starters, dynamic braking is provided so that when the switch is thrown in the "off" position the brake is applied. The starter is also so arranged as to lock open the reversing contact until the motor has come to a complete stop, so that it will be impossible for the operator to throw on the current for reversed rotation while the machine is still coasting in the one direction.

Some equipment, such as motor-operated fans, blowers, air-conditioning apparatus and similar units are sometimes operated at any one of a number of definite speeds. Remote control preset speed regulators are available for controlling such motors. These controls are comprised essentially of a control panel and a push-button station designating slow, medium and fast speed, and stop. The medium speed can be set to any one of five values by means of a dial switch located inside of the starting box. Further, by selecting various taps on the panel inside the switch, any one of three maximum speeds can be selected. Indicating lights on the starting box show which of the three speeds the motor is operating at and it is possible to change the speed by merely pressing one of the other buttons, upon which the motor simply changes its speed without an intermediate stop. These controls can be placed in parallel so that there will be a multiplicity of master stations, each one of which can control the speed of the motor.

In the operation of the remote control preset speed regulator, the change from one speed to another is effected by electric interlocks and not by mechanical actuation of the contactors on the resistors. It is for this reason that it is possible to mount a number of these master stations in parallel and control the motor from any one of them.

A great variety of auxiliary equipment is used in connection with motor controls, such as magnetic brakes or solenoid brakes, float switches, pressure regulating switches, temperature control switches and limit switches. These will be considered in the next article of this series.



Courtesy Tudor Metal Products Corporation

These simple stampings represent six different materials. The part in the upper right corner is made of sheet brass 0.002 in. thick

Materials for Stampings

J. K. OLSEN

Chief Draftsman, Stewart-Warner Corporation

In our highly competitive markets, the designs that use the least amounts of the least expensive materials must have the preference. Raw material is too often specified in accordance with past practice. But raw materials improve, their relative positions of usefulness change, and their market prices as well. The field for conservation of raw material is almost unlimited.

There are three main items in the selection of stamping stock, namely: material, thickness and temper. Additional factors that should be considered are: sheet or strip form, straight strip or coil stock, grain direction, grain size, chemical composition, finish, and heat-treatment. Many of these are interrelated.

The most common materials used for stampings are: aluminum, brass, bronze, copper, fibre, Monel metal, nickel, silver and steel. Of these, steel and brass predominate. Other things being equal, steel is probably a first choice, as it is cheap and strong. It can be obtained in tempers and thicknesses suitable for almost any form or shape and is easily heat-treated.

Cold-rolled strip steel is a high quality material. It is made by the basic open-hearth method, and is widely used for formed or drawn parts, especially where the limits are close. The harder grades of cold-rolled strip steel are generaliy used for such parts as washers, keys and other flat pieces. The softer grades are used extensively for drawn products. Cold-rolled strip is also used for knives, forks, shoe shanks, roller skates, chain links, and many other stampings.

For parts that do not have to be held to close limits in forming or bending, hot-rolled strip or sheet steel, being considerably cheaper than cold-rolled steel, comes into the picture. Its chief limitation is that it is not rolled thinner than 0.035 in., and then only in narrow widths. A thin and wide hot-rolled strip is more expensive than a cold-rolled strip. It should be remembered, however, that for cold-rolled strip there may be such additional operations as pickling, annealing and oiling. Another inexpensive steel material is the common hot-rolled mild steel. This is generally purchased in bar stock, and is ordinarily used for brackets and other supports.

There are various commercial grades of spring steel, one of which is hot-rolled sheet spring steel, suitable for numerous purposes, such as: harvesting machinery knives, hand shears, back springs, flat springs, shovels, wearing plates, cutlery and other parts requiring hardening. A higher grade of spring steel is the common clock spring. It is available tempered and polished in straw or blue colors.

Next to steel, brass is the most important raw material. There is something about brass that makes the designer, die-maker and production man feel confident that all production difficulties will be minimized. Brass is what a mechanic calls "a willing material." It is also a good-looking material, even when compared with modern and modernistic finishes. Commercial "high sheet" brass is the kind used for stampings. It is yellow, ductile, easily worked and will take a wide series of temper by cold rolling or drawing. It may be softened by annealing. The most used commercial composition is what is commonly known as $\frac{2}{3}$ copper and $\frac{1}{3}$ zinc, the composition corresponding to S.A.E. No. 70 and A.S.T.M. No. B-36 brass.

Brass is more expensive than steel, but it has many favorable features. There is no chance of adjacent brass and steel parts rusting together. In many electrical devices brass is called for on account of its non-magnetic property. Another feature is that brass makes an excellent base for plating, whereas steel must be plated with some base metal such as copper before the final finish plating is applied. Where a high-grade polish is required, as in reflectors, brass is preferred, as it is available in a finer grain than steel or most other materials.

Phosphor bronze strip is used for high-grade springs because it has a high endurance limit. Phosphor bronze serves both for mechanical and electrical parts and will in many cases serve where brass fails. It is more expensive than brass. S.A.E. grades No. 77A and B are usually specified.

Where weight is an important factor, aluminum is the choice. Aluminum alloys are divided into two main

classes, on the basis of whether or not they can be hardened by heat-treatment. In the first class the increase in tensile strength and hardness is accomplished by heat-treatment, or heat-treatment followed by aging. In the second class simple alloying and strain-hardening by cold work constitute the means of increasing the relative strength and hardness. The most common alloy used for sheets is the kind designated as 17S for strong aluminium parts. Alloys 2S (pure aluminum) and 3S are the most common specifications for deep stamping and difficult bending. Duralumin is, for practical purposes, merely a stronger aluminum and otherwise has the same characteristics.

One of the most common non-metallic materials for stamping is fibre sheet, used extensively for insulating purposes. It can be made to take a slight form and bend. Gasket materials also are usually stamped parts For parts that require more strength than fibre, what is commercially known as laminated linen and laminated canvas, are sometimes used.

Thickness of material is a factor that should be considered with utmost care as both the cost and weight of the part are proportional to the thickness. The commonly used sheet gages are the Birmingham wire gage, U. S. gage for steel, and the American, or B. & S. gage, used as shown in the following table:

Material	Sheet Gage
Aluminum	B. & S.
Brass	B. & S.
Bronze	B. & S.
Copper	B. & S., B.W.G. or weight
Fibre	Fractions of an inch
Monel metal	U. S.
Steel, H.R. Sheet	U. S.
Steel, C.R. Strip	B.W.G.
Steel, H.R. Strip	B.W.G.

It is unfortunate that different gages are used for the different materials. Many mistakes are made because of the confusion that is caused. It would be desirable if all sheet gages were replaced by one gage, for example, U. S. Standard. Furthermore, a designer must be extremely careful when changing from one material to another, as the different gages used may change the complete line-up of the design. In addition, changing from one material to another may often make it necessary to rework dies. Many mistakes can be avoided if designers adopt the practice of specifying the thickness in a decimal, eliminating both gage name and number.

Another source of confusion is the fact that the various materials have different thickness limits. Tolerances on cold-rolled steel are approximately one half of those for hot-rolled steel of the same nominal thickness. Both brass and phosphor bronze come within slightly closer limits than cold-rolled steel. Such other material as spring steel can be expected to come more nearly to exact thickness than the regular cold-rolled material. Aluminum tolerances approximate those for sheet brass.

Most materials have tempers from dead soft to spring temper, but there is a considerable difference in tempers for ferrous and non-ferrous materials. Obviously, the softer materials are always the choice for parts subject to extensive forming and drawing operations, and the harder kinds for strong and flat parts. In both steel and brass, soft temper is obtained by annealing.

Steel is readily hardened by heat-treatment. Brass is hardened by cold working. Because of the annealing necessary, the softer steel tempers are more expensive than the harder ones. There are certain designs in formed or drawn brass parts that call for removal of strains by annealing, which also adds to the cost.

For stampings, steel is divided into three types: low-carbon, mild and spring steel. Low-carbon steels have a carbon range from 0.08 to 0.15 per cent and are suitable for deep drawing. Mild steels, with a carbon range from 0.15 to 0.30 per cent, are useful for brackets, supports and parts made from bar stock. Spring steel, containing 0.50 to 0.05 per cent carbon, is, as the name implies, suitable for springs and highly tempered parts.

Cold-rolled sheet or strip steel comes in five tempers: hard, medium hard, soft, soft skin rolled or pinched, and dead soft. These tempers are known commercially also as full hard, half hard, quarter hard, skin rolled, and soft.

Hard steel is stiff and springy and should not be bent, either with or across the grain. It is intended, and is to be preferred, for flat work only.

An example of a deep drawn part made of extra deep drawing temper steel capable of being bent flat upon itself either with or against the grain

Medium-hard or half-hard steel is a material with considerable stiffness, but should be able to take a sharp right-angle bend across the grain without cracking. It should also be suitable for simple cold-working operations, such as slight drawing, cupping or forming. This material finds a place in many ordinary parts.

Medium-soft or quarter-hard steel should be able to bend down upon itself across the grain and should be able to take a bend of 180 deg. with the grain over a radius equal to the thickness of the stock; it should take a right-angle bend either way without fracture. It is also suitable for simple cold-working operations, and can be used for many ordinary parts.

Dead soft is the commercial, extra-deep, drawing temper, suitable for difficult bending work. It should be thoroughly annealed and can be bent flat upon itself both with and against the grain without any indication of cracking. To avoid wrinkling in shipping and handling, it is necessary to order it in straight lengths.

Soft-skin rolled is really the same

designation as dead soft, since the skin-rolling consists of only one additional rolling operation added to the dead-soft material. This operation reduces the stock approximately 0.0005 to 0.001 in., depending upon the thickness, and produces a harder and smoother surface. This material has the characteristic that it will pass through the more complicated draws without developing strains or an "alligator-skin" surface. It is suitable for parts to be polished, plated or enameled. The price of skin-rolled temper material should be the same as for the dead-soft material.

Any material that goes through a series of draws has a tendency to "fatigue," and the strains might result in cracks. It is therefore the practice to anneal the stock between draws even for dead-soft steel or brass and similar materials.

Especially in the smaller concerns, it is an advantage to concentrate on fewer than five tempers. The greatest number of parts can be made hard, medium-hard, and skin-rolled tempers. It may even be desirable to confine the tempers to only two, dead-soft skin-rolled and medium hard. Considering the many different thicknesses of stock available, it is easy to pile up a large number of different material items.

Hot-rolled Steel

One of the most common hot-rolled steels is the hot-rolled, pickled and oiled low-carbon steel. This material can be used for moderate drawing, embossing and right-angle bending work. A material with a higher carbon content sometimes called rigid hot-rolled steel, is suitable for flat punch-press work and for parts where stiffness and long wear are important. Hot-rolled, annealed, pickled and oiled steel is the choice for deep drawing, difficult forming and stamping operations. Dead-soft deep-drawing pickled, box-annealed and oiled steel is still another form and is suitable for extra-deep drawing and difficult bending work.

Steel bar stock has many commercial uses, especially with various forming operations. One of the most common of this kind is the commercial hot-rolled mild steel bar made from low-carbon steel. The temper is generally that resulting from the rolling process. Another steel, used mostly for springs and thrust washers, is medium-carbon black-tempered spring steel, available in a temper that is suitable for simple bends and forming. There are many different alloy steels in use, such as chrome or nickel alloys, and the temper can generally be obtained in the same range as cold-rolled strip steel.

For the various coated steels, such as tin plate and terne plate, specifications for the temper are quite general, the typical phraseology being: "The material must single seam without wrinkling or cracking," or "must be moderately deep-drawing quality."

Sheet Brass

Sheet brass has a commercial range of tempers larger than any other material. There are three soft grades and five hard brass tempers. Tempers for the hard grades are obtained by rolling the sheet brass and reducing the thickness two American or B. & S. gage numbers each time from half hard.

Soft-drawing anneal sheet brass is suitable for the most severe working operations and should only be specified where maximum or "true" softness is essential.

Drawing anneal sheet brass is suitable for parts requiring severe cold working without annealing, such as bending, spinning and fairly deep drawing.

Light anneal sheet brass is suitable for light cold working, and where some stiffness is desirable for parts that require light bending and slight drawing operations. This material is a very useful grade for many common parts.

Quarter-hard sheet brass is suitable principally for parts such as flat dials and other flat work, or for parts requiring slight bending and forming.

Half-hard sheet brass is suitable for etchings and flat work requiring stiffness and a good surface. It should not be used for parts requiring bending or forming.

Hard sheet brass is suitable for extra stiff parts and flat work where a fine surface finish is desired. This is another preferred temper.

Extra-hard sheet brass is suitable for flat work but should be used only for parts where extreme stiffness and an exceptionally high-class surface finish is the requirement.

Spring sheet brass is the hardest of the commercial tempers, and as the name indicates, it is suitable for flat spring parts and springs or other parts where springiness is the main requirement.

The commercial designation for phosphor bronze sheets corresponds to the temper designation of brass. This material is mostly used for parts such as springs and tension pieces.

Aluminum and duralumin sheet material is available in five commercial tempers: annealed, three-quarter hard, half-hard, one-quarter hard, and hard. This material also has a commercial code that is used for designating tempers. These designations are as follows:

- 0 Annealed
- H Hard rolled, hard drawn
- T Maximum heat-treated temper
- W Heat-treated and aged to room temperature
- RT Heat-treated, aged and cold worked

Other factors to be considered are, sheet vs. strip stock, straight strip vs. coil stock, grain direction, grain size, and composition and heat-treatment. The size of the part is one of the main factors in deciding if sheet or strip stock should be used. Another point is that strip stock purchased from the mill comes more uniform and closer to size than sheet stock. If straightness is not a requirement for the part, that is, if the part is to go through a series of drawing or forming operations, coil stock is to be preferred, as it is cheaper and can be used with automatic feeds. Restrictions in the use of coil stock are thickness and width of stock. Stock of soft steel up to 0.065 in. thickness can be handled in coil stock without trouble. There are instances where even $\frac{1}{8}$-in. stock can be used in this manner where the coil is fed some distance from the press. Brass can also be obtained in coil stock.

Surface Finish

Grain direction is a requirement that should not be taken advantage of unless necessary; in most instances it will affect the part cost, as a particular material layout may not be the most economical one. There are not many parts where the grain size has to be considered, as there are only a few examples, such as highly polished surfaces, where this requirement is necessary.

The surface finish is generally in proportion to the effort made in manufacture. Both cold-rolled and pickled hot-rolled steels can be expected to be considerably more suitable for high-grade finish than plain hot-rolled. In brass, and also in phosphor bronze, the surface finish depends upon the grain size and the number of rolling operations.

COMMUNICATION AND COMMENT

Bending Stresses in Curved Bars

BRUNO L. LONNGREN

The well known Bach's formula for a curved bar:

$$Stress = \frac{N}{A} + \frac{Bm}{Ar} + \frac{Bm}{CAr} \cdot \frac{y}{r+y}$$

contains a factor C which is given an analytical expression when the section to be analyzed is of few regular shapes, such as a circle, a rectangle, or a trapezoid. But these formulas are usually cumbersome for use in every day drafting room work, where theoretical accuracy sometimes has to give way to speed of approximation. For that reason it might be of interest and help to know a graphical and perhaps a faster method for finding the value of C, especially when the sections are other than mentioned. The method can be found in "Koneelimet" by Saraoja and will be described below.

Referring to Fig. 1:

N = component of load P perpendicular to section.

S = component of load P parallel to section, causing shear which is maximum in the middle of the section where bending stress is zero. For this reason S is disregarded in the analysis.

A = area of section.

Bm = Pl is considered positive when P tends to close the bend, negative when P tends to open the bend, as indicated in Fig. 2.

r = radius of curvature for the bend through the center of gravity of the section.

y = distance from the center of gravity of the section out to A or B, negative to A and positive to B.

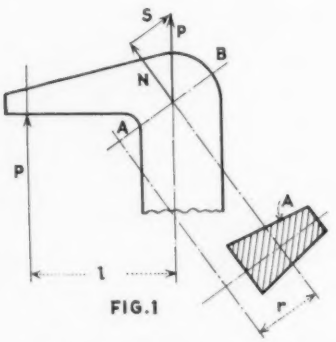


FIG. 1

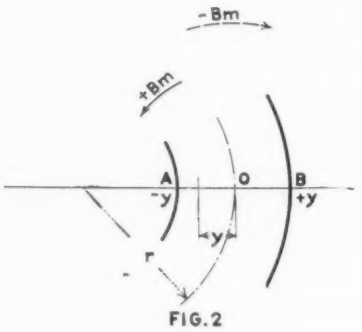


FIG. 2

Fig. 1—At section *AB*, the load *P* has the normal component *N* and the shearing component *S*. Fig. 2—When the load tends to close the bend, the bending moment is considered positive, and negative when the load tends to open the bend

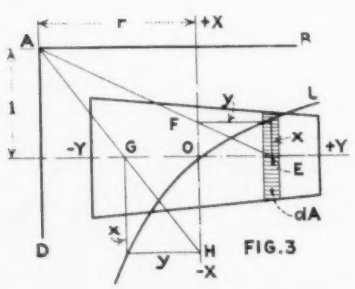


FIG. 3

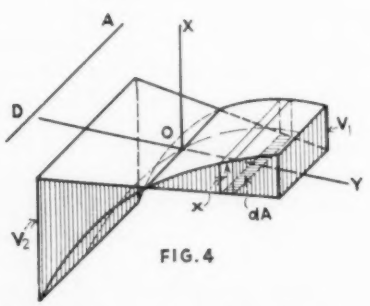


FIG. 4

Figs. 3 and 4—The graphical method for determining the value of the integral of $ydA/r + y$, as explained in the article

The constant C is determined from the equation:

$$CA = -\int \frac{y}{r+y}\,dA \quad or$$

$$C = -\frac{1}{A}\int \frac{y}{r+y}\,dA$$

We will now graphically analyze the integral.

In Fig. 3 the section A and the axis of curvature AD are to be considered to be known. In the center of gravity O of the section we place the axis XX and YY. At a distance of unity, 1, from the YY axis we draw AE to any point E on YY to the right of O. This line intersects XX axis at F, and the distance $OF = x$. From this we get the equation:

$$x : 1 = y : r + y$$

$$x = \frac{y}{r+y}$$

Therefore $\frac{y}{r+y}\,dA$ is the small parallelepiped, the base of which is the small area dA at E and the height is x.

If, on the left side of O, we perform the same operation and call the distance $OH = x$, we get:

$$x = -\frac{y}{r-y}$$

By taking several points E, O, G, etc., and for every point marking the distance x, we get the hyperbola L the asymptotes of which are AB and AD.

The integral expression $\int \frac{y}{r+y}\,dA$ represents the volume of such a body, the base of which is the section A and the height at any point the distance between the YY axis and the hyperbola as shown in Fig. 4. The volume V_1 above the base is to be considered positive and the volume V_2 below the base negative. Hence:

$$\int \frac{y}{r+y}\,dA = V_1 - V_2$$

In practical application of this

method it might be necessary to use a distance greater than 1 unit length when AB in Fig. 3 is drawn, so as to get more accurate values for x. Perhaps 2 or 3 times the unit length is used in which case it must be remembered that the volumes V_1 and V_2 are too large and a correction in the final answer for C must be made by dividing C by *2* or *3*.

When the volumes are computed the constant C is:

$$C = -\frac{1}{A}\left(V_1 - V_2\right)$$

As V_2 is always greater than V_1, then $(V_1 - V_2)$ is negative, and the value of C is positive.

Worm Gear Capacity

J. A. COVINGTON

In the February number, E. K. Ambler opened a rather pointed question when he brought up the matter of safe loads on worm gears. I would suggest that he procure catalogs of various worm gear manufacturers and sit down and compare the horsepower ratings of the different worm gears having the same size of teeth. He will possibly come to the conclusion that the capacity of the gear is largely affected by the name of the manufacturer rather than by the pitch of the teeth.

In all seriousness, I am wondering what really is the basis for the horsepower rating of commercial worm reduction units. From the investigations that I have made, there does not seem to be any logic in the wide spread between the ratings for the same size gearset given by different manufacturers.

Bolt and Nut Standards Not Ignored

GEORGE S. CASE, *President*
American Institute of Bolt, Nut and Rivet Manufacturers

In your April number Walter S. Brown wrote on "Accepted Standards That Are Ignored."

The American Standards Association, with the cooperation of many engineering societies, users and manufacturers, issued a schedule covering pretty nearly all of the hundred million dollars worth of bolts and nuts which were then being manufactured per year.

Production of castellated nuts is somewhat less than 1 per cent of the entire production. Mr. Brown is right that the schedules as first fixed have not been generally adopted, although I do not think he is quite correct in saying that they were ignored. They have been receiving constant consideration, and sub-committees have now worked out amendments in an effort to develop standards which more nearly meet the requirements of industry.

It is unfortunate that it is seldom possible to set up a one hundred per cent standard the first time, but when the manufacturers and users are adopting the American Standards to the extent of something like 99 per cent, they seem to be doing pretty well.

Mr. Brown has good cause for complaint on the castellated nut situation, but it is not being ignored and is receiving thorough attention. In defense of the American Standards Committee and the bolt manufacturers and users, I want to call attention to the fact that the American Standard is in use on the threads of practically all bolts and on an overwhelming proportion of other dimensions.

Simplifying Drafting Work

H. L. LACKMAN

It is often possible to effect economies in drafting work and simplify the drafting procedure through the application of specific methods and practices common with another company. For instance, in sheet-metal construction for all-metal aircraft, it is customary to have the same drawing serve for both detailing and assembly work. Many times a new job is very similar to an existing job, in which case only the changes are actually drawn in detail; the balance

DEFLECTIONS

CONTROLLED CLIMATE

Add to the data on air conditioning that it costs 20 cents per passenger to control the climate of a railroad car from Washington to New York. The cost of operation will thus be more than paid by one additional passenger per car.

•

BLACK LIGHT

"Invisible ultra violet, or 'black light,' to illuminate the instrument board, entirely removes all stray artificial light which would shine in the airplane pilot's eyes and at the same time makes the radium dial markings stand out in sharp image and many times their original brilliancy," according to J. H. Kurlander, engineer, Westinghouse Lamp Company, where this type of lighting has been developed.

•

CONTRAST

Just three short years ago a certain device was standard equipment on twenty-eight makes of automobiles. Thinking he had the market hog-tied and cornered, the manufacturer suspended all development work. He still feels that the fates treated him badly because all twenty-eight accounts have standardized on more modern devices.

Along about the same time, a New England manufacturer decided that "systematic improvement" of his product and his manufacturing processes might possibly pay. He writes as follows:

"As a result of this program, our sales record in the domestic field on this line was: 1929—$314,089; 1930 — $320,566; 1931 — $345,000. This result was achieved in spite of a decline in the whole industry in dollars during 1931 of about 12½ per cent as compared with 1930."

•

MATERIAL SELECTION

When the designer of a bus was asked whether he really saved any appreciable weight by using aluminum alloys for certain strength members in frame and body he replied that weight saving was not a factor in his choice. "The steel mills would not roll the 'odd' shapes for us, and the aluminum people would."

•

SAVED

Last month we recorded the fact that a new tank car for hydrogen peroxide had been built of aluminum alloy. What we did not know at the time was that the very first shipment saved $900 over the old method of transportation in hundred-pound glass containers.

of the assembly is merely a phantom over-all line with a reference to the original drawing.

The practice of describing small parts in words alone, instead of making a drawing, is often advantageous. When words alone might be confusing, a small freehand sketch, giving merely an outline of the original detail with a full-line drawing and dimensions of the additional work required, will often answer the purpose. Many parts may be specified merely by their trade name and number. Large units purchased under a trade name and installed as an additional part after the original assembly is in service may be best shown by a photograph which indicates how the special unit is applied. This is often clearer than the use of a three-view drawing.

Pros and Cons on Bills of Material

L. L. Leach
Engineering Department, Fuller-Lehigh Company

Relative to the item by P. Hall in the June number, there are three ways of caring for the complete bill of material. One is by placing it on the assembly drawing of the machine. The second method is to place the bills of material on the detail drawings, and the third method is to make a bill of material on a separate sheet.

If the machine is small, it is possible to place the entire bill of material on the assembly drawing. Each item that is detailed on a separate drawing must of course be referred to, and the parts must be completely marked and shown on the assembly drawing. This method has the advantage of facilitating the ordering of material as the order department has but one place to look for the complete list of the component parts of the machine. Also, it is an aid to the mechanic making the assembly to have the parts list on that drawing.

However, as the machine becomes more complicated this scheme becomes cumbersome. It is difficult to show every cotter pin, lock-washer, key, screw and other small items on the drawing, and if the parts are not drawn but merely billed, it sometimes becomes quite difficult for the assembly man to identify each piece. It also makes ordering parts difficult.

Another difficulty is that if a change is made in the detail drawing, it might require a change in the assembly drawing bill, thus making it necessary to issue a revision for two drawings. For example, a keyway may be added, thereby requiring another key. If the keyway is shown on one drawing and the key billed on another, both must be revised.

As the assembly drawing becomes more complicated, the assembly drawing may refer to a number of sub-assembly drawings, and these sub-assembly drawings may carry the bill of material. This scheme is also an aid to the mechanic on the assembly floor if the sub-assembly is not so complicated as to entail the objections mentioned above. Likewise this scheme is an aid to the order department. However, it is open to the same objections that apply if the bill is on the assembly drawing, causing confusion in making revisions.

The system of placing the bill of material on the detail drawing of the individual part is probably the most universal method employed by builders of machines. If the machine is one that is to be built in quantity, each piece that requires a detail is drawn on a small sheet; no sheet will have more than one piece detailed on it. Standard items that require no detail drawings and that are used in conjunction with the piece are listed on the same sheet with the detail drawing. For instance, a shaft detail may list in its bill of material, ball bearings, clamping nuts, cotter or taper pins, and keys. The detail of a stuffing box would list the packing required. All bolts are listed with the piece against which the head of the bolt rests, and all studs and screws are listed on the detail drawing of the piece into which they screw.

Some companies make special bolt lists, and tie up the article in the list with the instructions for the hole. But the arrangement requires issuing revisions on two drawings for some changes where but one revision is necessary if the bolt is listed on the detail part. It also requires that the shop man refer to the bolt list to find the required bolt to hold two pieces together, when it could be listed on one of the two pieces concerned. The only advantage of the separate bolt list is to facilitate ordering and supplying the parts. However, with some equipment the number of bolts and similar parts is large, and it is desirable to list them separately.

This arrangement of placing the bill of material on the detail part permits any given detail piece to be used on any number of machines. However, if the quantity of the part in question varies with the different machines, then a table must be added to the detail to stipulate the number required for each machine.

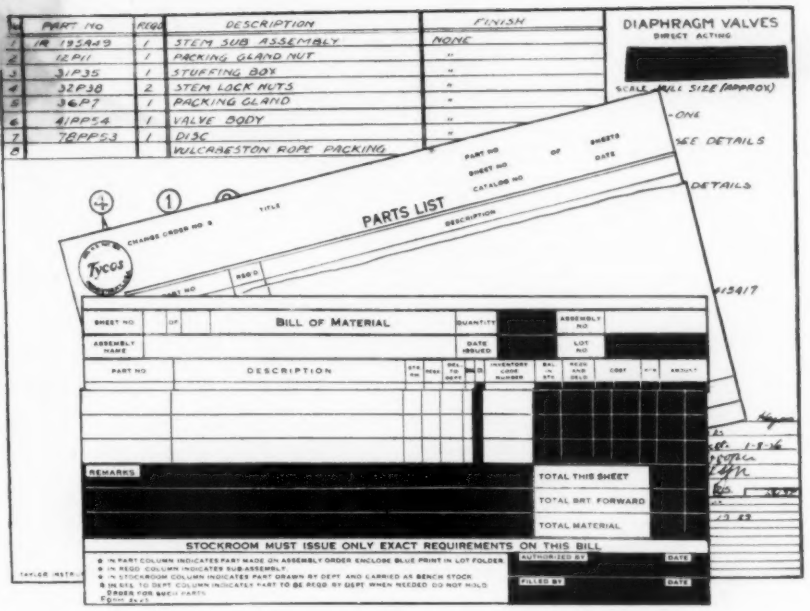
Companies that design special equipment, detail many items on one sheet. With this system there is little advantage in placing the bill of material on the assembly. Making the bill of material on an independent sheet has its advantages where the parts are used in various quantities for different pieces of equipment or the unit is built up largely of standard parts. This system simplifies clerical work in ordering but requires two changes to alter one detail.

Bills of Material Versus Unit Parts Lists

M. W. Elmendorf
Chief Draftsman, Taylor Instrument Companies

Up to a few months ago it was customary to hand-letter a complete bill of material with appropriate reference numbers not only on assembly but also on sub-assembly drawings. In addition to this we had a separate parts list which was practically a duplicate, but on a separate sheet. The production department also converted this same list into a so-called bill of material, many times grouping together various details for the convenience of production. This meant three sources of information, which of course is always expensive and conflicting.

Several months ago it was decided to combine all these features into a



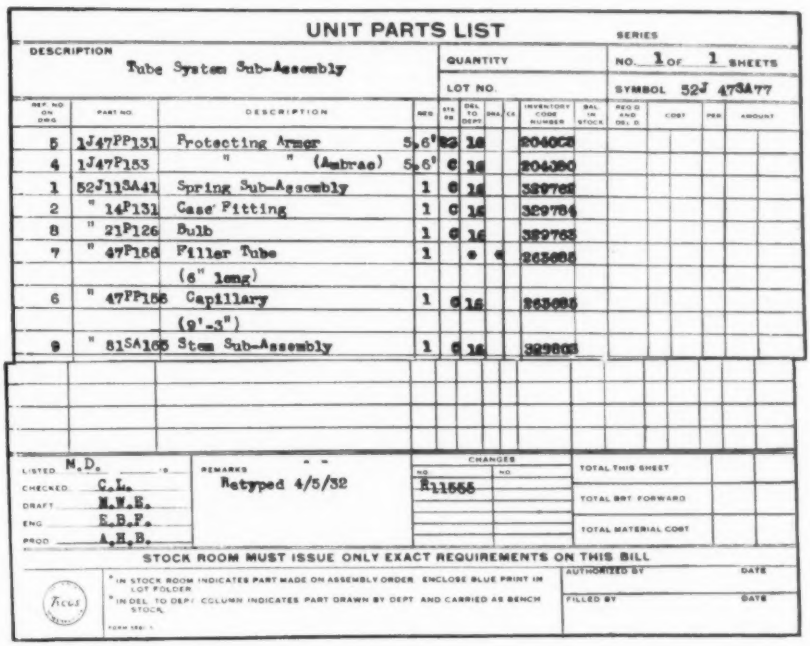
Under the old system, the complete bill of material was lettered in on the assembly drawing. In addition, two separate lists were made, one for the stores department and the other, a grouped list, for the production department. This duplication made it difficult to put through charges

new form called Unit Parts List on which appeared reference numbers for the assembly or sub-assembly drawing, description of the detail and number required. This much corresponded with the old bill of material formerly on the drawings, so it was decided to omit these from our tracings. The balance of the Unit Parts List contains spaces for the routing of the parts from the various stockrooms to their destination, an inventory code number, balance in stock, the number required of each detail for the lot and, in addition, columns for cost figures. It is obvious that this parts list serves the purpose of the other three mentioned above. It not only covers the component parts of any assembly or sub-assembly but is used as a stockroom requisition, routing card and cost sheet. Incidentally, it controls each lot automatically so that the cost must be exactly as produced and conform also to the drawing. No alterations are tolerated on the Unit Parts List without an authorized change. These Unit Parts Lists are reproduced by means of Ditto machines, but to play safe, the originals are put on transparent parchment so that in case the Ditto ink wears out they may be blueprinted.

This plan has been working out nicely with little steering, but lately some complaints have been received from various factory units that the absence of the bill of material on assembly and sub-assembly drawings creates delay, therefore working a hardship in production. Of course, if the assembly or sub-assembly blueprint is always accompanied by its corresponding Unit Parts List, there should be no cause for complaint, but in our organization it so happens that files of permanent reference prints are not maintained in the various production units because the setup is such that up to date blueprints are issued for each lot in the folder method of production. We have about decided that to offset these complaints and preserve harmony, we should again go back to the old method but are reluctant to do so until we are more firmly convinced that we are not on the right track and that the supplying of more available Unit Parts Lists will not satisfy these complaints.

The advantages of the Unit Parts List, taking its use in the organization as a whole, are many, and the plan should be workable in many other plants. We have found the Ditto reproduction much cheaper and faster than blueprints, and in fact, so cheap that we keep a minimum stock of six or eight sheets on hand at all times for immediate issue, thereby preventing delays.

We are interested in reading discussions by others on such a setup as described here as we still think it is in the experimental stage and may require some modifications. Perhaps there may be other organizations that have tried out both of these systems over a period of years, and are thereby in a position to give recommendations based on practical experience.



Under the new system, there is only one list on a separate sheet, and it contains the information required for all departments. The lists are reproduced on Ditto machines

Seventh Pilgrimage to Langley Field

May 25, too late to be reported in the June issue of *Product Engineering,* which went to press on May 20, the engineering talent of the aeronautic industry made its seventh annual pilgrimage to Langley Field to learn what progress is being made in the research work of the National Advisory Committee for Aeronautics. Attendance was apparently unaffected by business conditions.

Already the effects of the full-scale wind tunnel are being felt in the fundamental research programs of the Committee. A check of the tunnel results shows agreement with actual flight results within 2 per cent. A speed of 58½ m.p.h. has been obtained in the new towing basin, and the program for this apparatus is well under way.

As the several fundamental research problems under investigation unfold, the high degree of coordination between the various sections of the laboratory becomes increasingly apparent. The breadth of viewpoint attainable on a single problem through the process of breaking it down for separate study by each of several sections produces results invaluable to engineering progress. With the curtailment of individual research by private units in the industry, the work of the Committee is receiving even greater appreciation from engineers in the field.

In the variable density tunnel, sixty airfoils have been studied to learn the aerodynamic effect of changes in thickness and camber. As a result better sections have been developed for particular application. Through the use of a high speed wind tunnel it has been possible to test airfoils up to about 90 per cent of the speed of sound, or nearly 700 m.p.h. It has been found that the minimum drag coefficient of a symmetrical airfoil of 12 per cent thickness is nearly constant at all speeds up to 500 m.p.h. At that point compressibility takes hold, and between 500 and 600 m.p.h. there is a rapid increase of drag coefficient to five times the normal value.

The sharp rise of drag at very high speeds corresponds to a definite loss in propeller efficiency when tip speed passes beyond 1,000 ft. per second, which had previously been observed. Some engineers present were therefore led to the conclusion that a speed somewhere between 500 and 600 m.p.h. is the limit for airplanes.

Among other things discussed was the vital question of where engines should be placed in airplanes. The mean efficiency of tandem propellers is shown to be 5 per cent less than that of a single propeller; properly cowled single engines prove to be better than tandem engines. A single cowled engine above the wing shows a net efficiency of 0.63 and a cowled nacelle sunk in the wing gives 0.75, the best value among all the positions tested.

Preliminary experiments with the use of safety (hydro-generated) fuel have shown abnormally high consumption, but it has been possible to reduce this by the use of higher compression ratios and high-temperature cooling. The comparative performance of three-engine airplanes with equal powered diesel and carburetor engines were computed. Results inindicated that for equal pay loads, maximum speeds, and cruising speeds, an airplane equipped with diesel engines would show a 40 per cent increase in cruising range and a decrease in fuel cost per mile (at present unit cost) of 64 per cent.

The session closed after a brief appeal from Commandant Kirtland to the visitors to appreciate the personnel problem of the Army Air Corps, particularly in the event that expansion should suddenly become necessary as in the not far distant past.

Materials and Practices at A.S.M.E.

Two papers of general engineering interest stood out at the meeting of the aeronautic division of the American Society of Mechanical Engineers, Buffalo, N. Y., June 6 to 8.

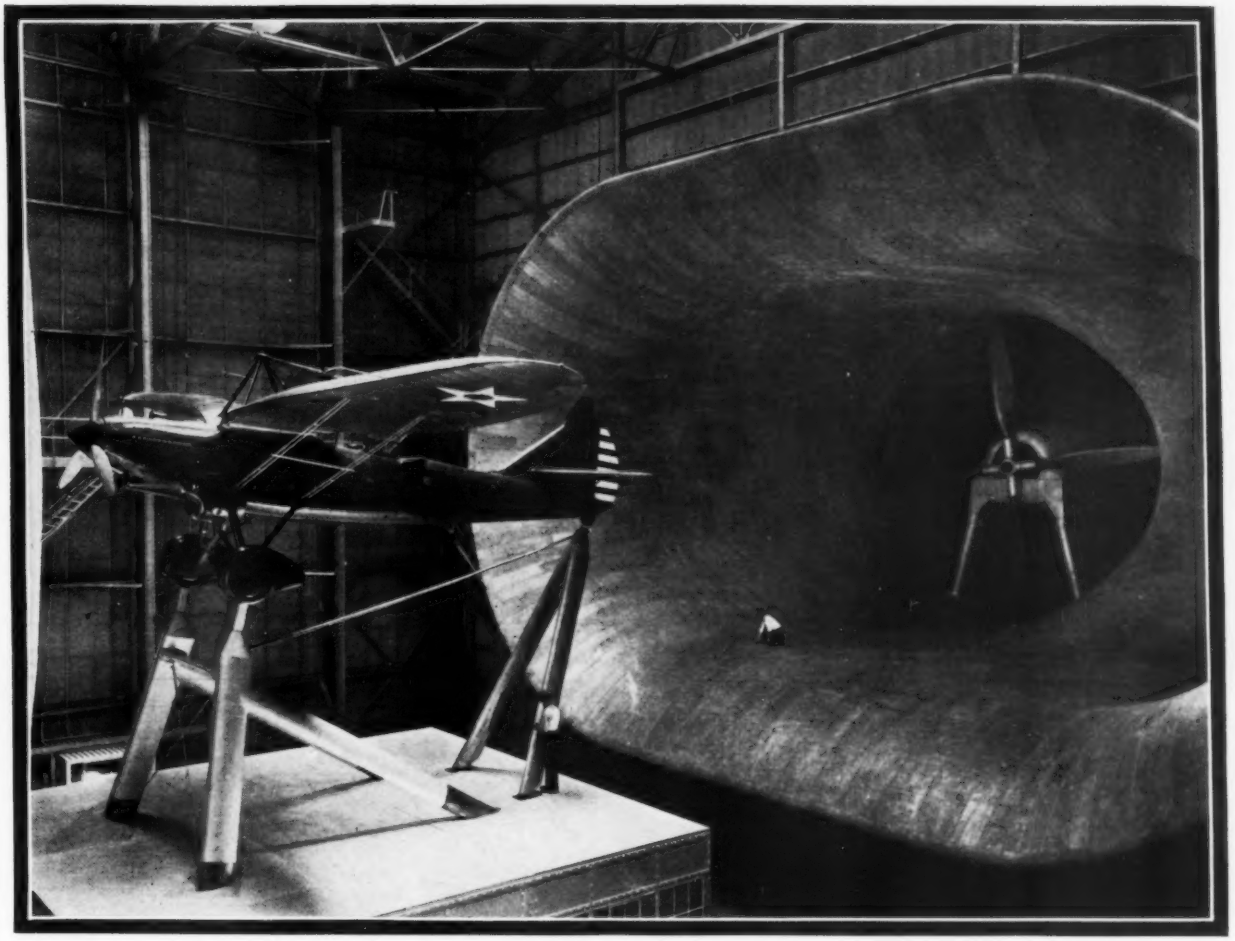
"Developing Aluminum Alloys in Relation to Aircraft Construction," by C. F. Nagel, Jr., technical director, U. S. Aluminum Co., and G. O. Hoglund, aeronautical engineer, Aircraft Development Aluminum Co., outlined the advances made in high-strength aluminum alloys. Starting in 1920 from a tensile strength of 25,000 lb. per sq.in. they have advanced to 60,000. They also announced that a new alloy of the duralumin type to be known as 24S is soon to be available. New aluminum alloy tubes are guaranteed to have a minimum yield point of 52,000 lb. per sq.in. Resistance to corrosion has also been considerably increased, some samples having been exposed to 20 per cent salt spray for five years without injury.

Experience with the lighter alloys in various factories has developed workmen who now handle this material as easily as steel. Heat-treating in the fabricator's plant is eliminated, all of which reduces cost and insures maximum corrosion-resistance. Electric spot welding of aluminum alloys seems to be on the way, at least two planes having been built by this method. In both instances, spot welding was used in place of riveting in a large proportion of the joints.

In his paper, "Stainless Steels in Aircraft Construction," Colonel E. J. W. Ragsdale, research engineer, Edward G. Budd Mfg. Co., gave the first comprehensive explanation of the "shot welding" process, now famous for its part in the construction of the Budd-Michelin railway car.

Since 18-8 achieves its maximum resistance to corrosion only after a certain heat-treatment, it should be clear that any subsequent heating may affect its stainless qualities. Such heating occurs in welding, and a method was sought whereby alteration in corrosion-resistant properties could be eliminated and the strength of the metal retained in spot welding. "Corona" has been the bugbear of the spot welder; its extent has been known to be a function of time and current.

Consequently, Edward G. Budd Mfg. Co. developed a welding ma-



Douglas YO-31A military observation plane mounted for test in the full-scale 60x30-ft. Wind Tunnel, Langley Field. A maximum wind velocity of 115 m.p.h. is produced by the 4,000 hp. motor fan. So great is the pull on local electric power lines that all tests must be conducted between midnight and dawn. The pilot operates the engine and controls, and the results agree with actual flight tests within 2 per cent

chine, the features of which are: absolute uniformity of current supply, use of high currents for a very brief controllable period of time, and a recorder which supplies visible and audible record of performance. This machine, known as the shot welder, produces corona-free welds consistently, thus automatically opening up a large field of stainless steel. In his paper, Col. Ragsdale stated:

"In shot or spot welding, the diameter of the fused slug should have some reasonable relation to the thickness of the sheets to be joined. No closed section can economically suffer large welding flanges, for it is here that compression failure initiates. Shot welding encourages the use of a narrow flange—much narrower than would obtain in a riveted connection —and, in consequence a spot not greater in diameter than three times the double thickness of material should be used. The flange in turn should be at least three spot diameters in width. . . . There is no need for large areas of fusion, since good welds will show twice the shear of a rivet of like diameter and can be spaced 50 per cent closer together. Shear is not the only test for welds; they must be tough enough to permit rotation through at least 60 deg." It is worthy of note that the heat which goes into a single shot weld in two pieces of 0.012-in. material is but 0.035 B.t.u. This also explains how assemblies can be made without distortion.

Shot welding through several thicknesses is possible, being frequently done; nor do the pieces have to be of equal gage. The diameter of the spot is determined largely by current and time rather than by the size of the electrodes.

"Shot welding makes the use of stainless attractive in experimental work. . . . For small structures, the only jig required consists of a number of wooden blocks nailed over the blue print. For more elaborate ones, a wooden frame is erected and significant points are notched out. The component strips which go to make up a closed section are, in themselves, flexible and can be naturally bent to even sharp curvature. They are then welded together and attain the rigidity peculiar to a closed member."

As to the speed of shot welding, "one operator can average 10 welds a minute on complicated work and 40 on fairly straight seams. Machine welding has no apparent limit. Using only one pair of points, 100 welds per minute have been consistently made."

S. A. E. Discusses Diesels

Many papers of highly specialized automotive interest found their place on the program of the summer meeting of the Society of Automotive Engineers, White Sulphur Springs, W. Va., June 12-17. Of more general

engineering import was the paper of R. P. Ramsey, chief engineer, diesel division, Buda Company, "Design Factors and Combustion Control Determine Future of Automotive Diesels." According to Mr. Ramsey, a good demand exists for the 500-cu.in. diesel, but a gasoline engine of comparable size can be produced more cheaply at present.

To produce an automotive diesel satisfactory in cost, weight, power output, performance and speed, the following qualifications must be met: (1) Brake mean effective pressure must be comparable to that of the gasoline engine at comparable combustion pressures; (2) It must idle without dilution; (3) Compression should not be so high that the engine is rough and economy is lost at high speeds; (4) Ignition noise must be commercially acceptable; (5) The system must be proof against occasional excessive pressures set up by over-injection of fuel; (6) It must not be sensitive to changes in fuel quality; (7) It must have non-clogging nozzles; (8) Timing must be roughly adjustable. An engine of the 500-cu.in. class, Mr. Ramsey predicts, will weigh 12 to 15 lb. per hp.

Engineering Trends at N.E.L.A.

Flanked on either side by the comprehensive exhibits of the two largest manufacturers in the electrical field, the 55th Convention and Exposition of the National Electric Light Association held forth from June 5 to 10. Approximately 100 manufacturers exhibited their products. In his address "Some New Engineering Problems," Charles F. Kettering, vice-president of General Motors Corp., suggested that if you carry standardization too far, you are inevitably led to cut-throat price competition, low profit and stagnation.

It is unfortunate, but true, that many of the exhibitors showed by their products that they were simply playing the grandiose game of follow-the-leader. A year or two ago, an electric range manufacturer brought out a line in cabinet style. This year, we find other manufacturers following him all too closely. Any number of manufacturers showed lines of electric water heaters. Table type electric laundry ironers appeared on very side. Several designers must have found someone to follow in combing porcelain with chromium-plated metals for various electric table devices.

On the other hand, it is not altogether fair to generalize too broadly. Several manufacturers were there with products that showed genuine originality and clever engineering design. These items will be found included in the Product Developments department of this issue. In his address, "Research—The White Hope of our Industry," Samuel M. Kintner, vice-president of the Westinghouse Electric & Mfg. Co., sounded a warning that should be plastered on every billboard in the country: "If management decides to forget further development for the time being it is on exceedingly dangerous ground; the march of progress is relentless; there is nothing that is quite so ruthless; it behooves all management to keep keenly alive to the necessity of meeting changes at all times."

Engineers of 18 Nations Meet to Standardize

On June 9 there ended a series of technical conferences aimed to secure international uniformity in standards for airplane and automobile parts, center heights and dimensions of shaft ends of electric motor driven machines, ball and roller bearings, iron and steel, screw threads and several other important projects. According to the announcement of the American Standards Association conferences have been held under the auspices of the International Standards Association which includes in its membership the national standardizing bodies of the United States, France, Germany, Italy and 14 other nations. Owing to the fact that the sessions were held in three languages it may be some time before a complete report can be rendered on the findings of the meeting.

S.P.E.E. Joins A.E.C.

Arrangements have been completed whereby the Society for the Promotion of Engineering Education becomes a member organization of the American Engineering Council. This is an important step in the development of the organization of the engineering profession, because the Society for the Promotion of Engineering Education is the foremost exponent of engineering education in the United States. Many problems of concern to the engineering profession, which are acted upon by the American Engineering Council, involve the future of engineering education.

Post Graduate Course in Kinematics

Brooklyn Polytechnic Institute announces, that it will offer a post graduate course in theoretical and applied Kinematics during the coming year. It will present, besides new and simple methods for the analyzing of motions, a complete systematic classification of machine elements, kinematic chains, mechanisms and machines, and a general method of making a kinematic analysis of machines, leading to the kinematic synthesis of machines to be designed.

These methods will provide designers of complicated machinery with the scientific tools for securing results quickly and directly without the usual process of trial and error. Further information may be obtained from the Institute.

Meetings

No engineering meetings or expositions of national importance are scheduled for the month of August.

A.S.M.E.

National Wood Industries meeting of the American Society of Mechanical Engineers is scheduled for Sept. 19-23, at Jamestown, N. Y., together with a commercial and educational exhibition. Calvin W. Rice, 29 West 39th St., New York City, Secretary.

A.S.S.T.

Sponsored by the American Society for Steel Treating, The National Metal Congress and Exposition will be held Oct. 3-7, 174th Regiment Armory, Buffalo, N. Y., with the American Society of Mechanical Engineers, Institute of Metals, American Institute of Mining Engineers, American Welding Society, and The Wire Association cooperating. W. H. Eiseman, 7016 Euclid Ave., Cleveland, Director.

Engineers and their Activities

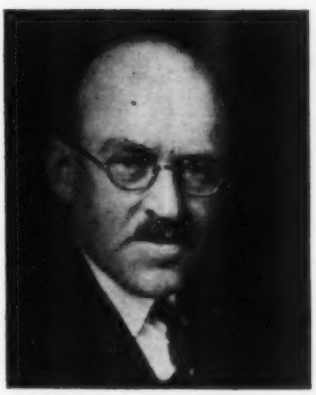
George Ainsworth

GEORGE AINSWORTH, illumination engineer and authority, has joined Westinghouse Electric & Mfg. Co., East Pittsburgh as a consulting engineer on semi-indirect illumination, placing his wide experience at its exclusive disposal. Lighting units of his design may be seen in prominent buildings all over the world.

C. M. Chapman

DEAN F. L. BISHOP, University of Pittsburgh, has been chosen as the first delegate of the Society for the Promotion of Engineering Education to the American Engineering Council. His devotion to the cause of engineering education has extended over many years.

CLOYD M. CHAPMAN, consulting engineer, New York City, has been elected president of the American Society for Testing Materials. A Cornell M.E., of the class of '98, he began his career as engineer officer in the Navy during the Spanish American War. At its close he became assistant to Edison in his private laboratory; from 1905 to 1920 he was employed by Westinghouse, Church, Kerr & Co., since which time he has been actively engaged in his consulting practice. He is a member of several societies and is chairman of the Standards Council of the American Standards Association.



R. E. Flanders

RALPH E. FLANDERS, manager, Jones & Lamson Machine Co., Springfield, Vt., and international authority on screw threads, received the honorary degree of mechanical engineer at the sixtieth commencement of Stevens Institute of Technology. His citation read in part as follows: "industrial executive, author, analyst of social problems peculiar to this age of mechanical perfection, a lay philosopher whose approach is significant of a specialist in engineering."

A. H. GEORER, chief engineer for the past thirteen years of the Automatic Transportation Company, Chicago, and in addition to these duties, chief engineer of the Barrett Cravens Co., Chicago, for the past three years, is leaving these positions June 30, with no definite plans for the future. He has been connected with the material handling industry in all its phases since 1910.

GEORGE A. GREEN has been advanced from the position of vice-president in charge of engineering of General Motors Trucks Co., Pontiac, Mich., to that of vice-president in charge of operations. He will continue in charge of G.M.T. engineering.

W. JENSEN, formerly chief engineer of Allied Die Casting Corporation, has become works manager of the newly organized Advance Pressure Castings, Inc., 34-48 N. 15th St., Brooklyn, N. Y.

F. L. LINDEMUTH, formerly with Mesta Machine Co., has been appointed chief engineer of the William B. Pollock Co., Youngstown. O.

WILLIAM WESTERVELT NICHOLS, vice-president and mechanical engineer, J. P. Brown & Co., Detroit, was recipient of the honorary degree of mechanical engineer from the University of Detroit. The citation reads in part, "an outstanding figure in the profession of mechanical design, creative engineering and industrial management; and for his additions to the literature of industrial management and problems of industrial control."

ALOIS H. SCHMAL, formerly executive engineer of International Motor Co., has been placed in charge of the automotive division, engineering department, SKF Industries, Inc., New York City.

ADOLF G. SCHNEIDER, who was chief designer for air controlling units, T. H. McCormick Co., and prior to that chief designer, Lycoming Mfg. Co., has been made chief designer of the Northern Pump Co., Minneapolis, Minn.

THEODORE A. WELLS, who was project engineer of the Curtiss Wright Airplane Co., Robertson, Mo., has been appointed chief engineer of the Beech Aircraft Co., Wichita, Kans.

ERNEST WOOLER, chief engineer, Timken Roller Bearing Co., Canton, O., was the American delegate to the International Conference on uniformity in standards which just ended at Milan, Italy. He discussed before a special conference on ball and roller bearings the American proposal for replacing many of the different types and sizes now manufactured in the United States alone.

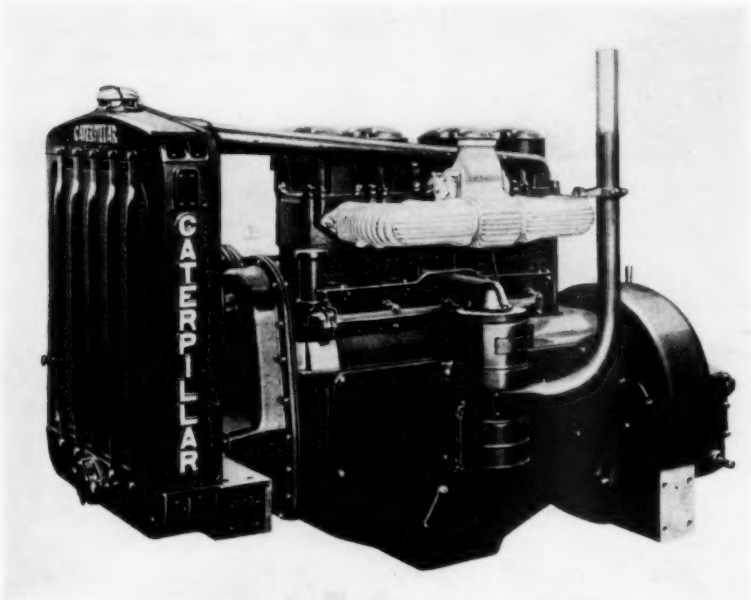
NEW MATERIALS AND PARTS

Caterpillar Engine Units

The Caterpillar Tractor Co., Peoria, Ill., offers to machinery builders its line of tractor motors adapted for stationary uses. Six sizes of gasoline engines and a diesel powered unit are available. Typical of the line, Model 7500-G is a 4-cylinder, valve-in-head motor, with a bore of 5½ in., stroke 6½ in., and displacement 617 cu.in. The designed speed is 850 r.p.m., but the motor will operate continuously at 950 r.p.m. Other units in the line consist of the following:

Model	Bore and Stroke	Speed r.p.m.
D-9900 (Diesel)	6⅛x9¼	700
9000-G	7 x8½	650
7500-G	5½x6½	850
6000-G	4⅞x6½	850
4200-G	4 x5½	1100
3400-G	3¾x5	1250
2400-G	3⅜x4	1500

All but the last two models can be furnished either as engines or as complete power units consisting of the engine mounted on steel skids, radiator, lowered hood, fuel tank and clutch. Models 3400-G and 2400-G are engines only. Except on the diesel, ignition is by Eiseman magneto with automatic impulse coupling. An Ensign 1½-in. S.A.E. vertical carburetor is standard.



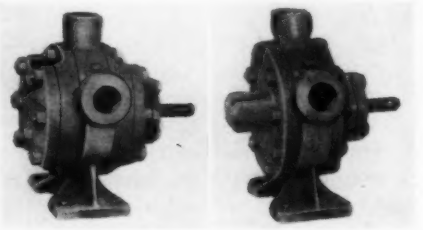
Caterpillar No. 7500-G gasoline engine

Roper Series 996, 998 and 999 Hydraulic Pumps

To supplement its series 909 hydraulic pumps built for 1,000-lb. pressure, the Geo. D. Roper Corp., Rockford, Ill., has brought out three other series for lower pressures and somewhat different classes of service. All three types of pumps feature herringbone gears, one of steel, the other of brass, pressed onto the drive shafts. The pumps are intended for direct motor drive and can be furnished mounted on a common bed plate with space provided for N.E.M.A. standard motors. If chain or belt drive is desired, an outboard bearing can be furnished.

Series 996 pumps are for hydraulic power transmission, for use on machine tools, elevators, portable lift trucks, requiring not over 300 lb. per sq.in. pressure. Single-row ball bearings pressed on the shafts without locknuts, are standard on this pump. Because ball bearings are used, the pump is suitable for use with lubricating liquids only. This style of pump comes in nine sizes, varying in capacity from 4 to 100 gal. per min. at 0 head. Larger capacities are also available.

Series 998 pumps are of the same capacity and are similar in design to the Series 996, except that they employ sleeve bearings. Lubrication of bearings is furnished simply and directly by the hydraulic medium. It is not, however, necessary to employ lubricating liquids. Ordinarily the pump bodies are made of cast iron, but other materials, such as bronze, can be furnished to give maximum resistance to corrosion of the hydraulic medium.

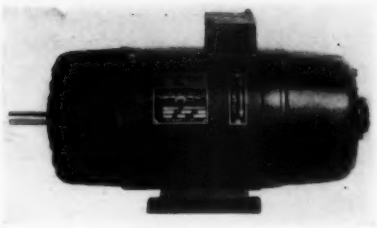


Left—Roper Series 996 Hydraulic Pump
Right—Series 999

Series 999 pumps develop pressures to 100 lb. per sq.in. These pumps also have sleeve bearings. This series is made in ten sizes with a capacity range of 1 to 100 gal. per minute.

Esco Constant Speed Generator

Electric Specialty Co., Stamford, Conn., announces a constant speed generator with automatic clutch designed to deliver constant output voltage and a.c. frequency when driven from a varying speed source. The device consists in a self-excited alternator, with d.c. windings for field



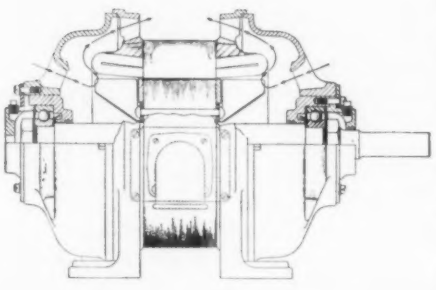
excitation, which may also be used for charging a storage battery, if desired, and with a.c. windings delivering 60 cycles, a.c. at 1800 r.p.m. The working faces of the special centrifugal clutch are covered with a special lining claimed to have constant coefficient of friction throughout a very wide range of activity. The entire machine is furnished totally inclosed, with ribs on the clutch housing to dissipate heat. Non-corrodible parts are used throughout.

Anaconda Electrolytic Sheet Copper

Produced by an electro-plating process in widths up to 30 in. and in any length, Anaconda electrolytic sheet copper may be secured on special order from American Brass Co., Waterbury, Conn. Thicknesses range from 0.001 in. up, specifications being based upon so many ounces per sq.ft. Exceptional purity and high conductivity are claimed.

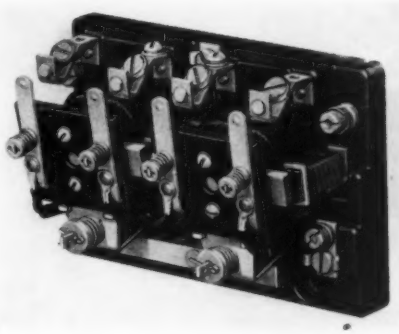
General Electric Screenless Open Textile Motor

A screenless open motor designed to meet conditions encountered in various manufacturing processes connected with the textile industry, where the atmosphere is heavily laden with floating particles of lint, has been announced by General Electric Co., Schenectady, N. Y. No attempt has been made to prevent lint from entering the motor. Air passages have been so constructed that as soon as lint enters the motor it is immediately blown out. This improvement is made possible through the following features of construction: (a) Smooth glossy windings to which lint will not adhere. No pockets or recesses in or about the windings. (b) Large frame and shield openings which allow lint to pass freely in and out, and (c) Dust- and oil-tight bearing housings. Cost of the motor is comparable with that of the standard open-type motor.



"Square D," Class 8711 A.C. Reversing Contactors

Square D Co., Industrial Controller Div., Milwaukee, Wis., has brought out an a.c. reversing contactor, Class 8711, Type K. This contactor is of small dimensions and is particularly adapted to small hoist, dumb waiter, window and door control. Contactors are mounted on a porcelain base, are mechanically interlocked, and have silver-to-silver contacts. Maximum rating is $\frac{3}{4}$-hp., single or 3-phase. Dimensions are 6 in. wide by 4 in. high by $3\frac{1}{4}$ in. deep.



Eraydo Zinc Base Alloy

A new patented zinc base alloy, containing about one per cent copper and a fractional per cent of silver, is being marketed under the name of Eraydo by Illinois Zinc Co., 332 S. Michigan Ave., Chicago, Ill. It has a tensile strength about twice that of common zinc, and with an annealing, or recrystallization, temperature of from 300 to 450 deg. F., depending on temper, instead of the low room temperature figure of pure zinc. It is produced in sheet and strip form in four tempers or grades of hardness. The softest temper has the ductility of pure zinc with a 50 per cent increase in tensile strength. Harder tempers with somewhat less ductility reach a tensile strength value equal to twice that of common zinc, and possess good forming qualities.

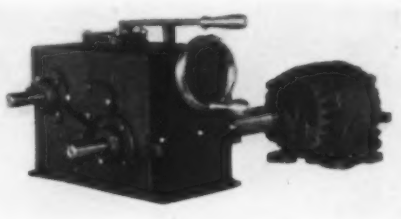
Its increased hardness results in a beautiful chromium-like luster after buffing; and clear lacquer coatings have been developed which preserve this beautiful finish for long periods.

The metal casts very well either in sand or by die casting. Aluminum has been purposely excluded, in order to avoid intercrystalline oxidation and swelling in moist atmospheres. Therefore, the metal must be die cast in a machine in which there is no opportunity for iron pick-up by the molten metal. Several of the new designs of die casting machines are satisfactory for this purpose. Test bars, die cast, give an impact value of over 400 ft. lb. per sq.in. (Charpy $\frac{1}{4}$ in. square specimen).

The metal performs well in common manufacturing operations. It is easily plated, soldered, forged, drawn and spun. It is supplied in rod or wire form in either a free cutting grade or a tough condition which is used for cold heading work.

Lenney Variable-Speed Transmission and Reduction Unit

This variable-speed transmission and reduction unit combined has a speed range from 15 to 150 r.p.m., with motor running 1,750 r.p.m. It has just been developed by Lenney Machine & Mfg. Co., Warren, Ohio. Forward, neutral and reverse can be accomplished by a shift lever while the motor is in motion. Speed is controlled by a handwheel located on the box, and speed may be changed while the unit is in motion. The motor is coupled direct. The manufacturer claims more quietness for the design. Speed ratios other than those mentioned can be furnished on order.



G-M No. 1291 Photoelectric Relay

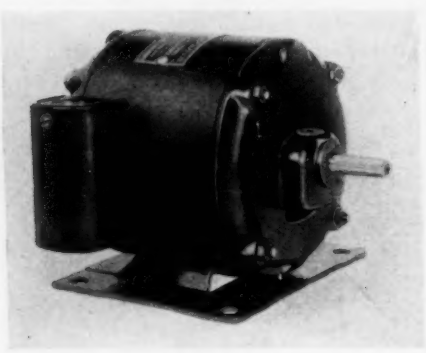
A new photoelectric relay is being brought out by the G-M Laboratories, Inc., 1735 Belmont Ave., Chicago, Ill., embodying means whereby all wiring can be concentrated at one point. The unit combines the amplifier, photoelectric cell and light source within a single case and is capable of operating at speeds as high as 600 light interruptions per minute. The rays from the lamp behind the right-

hand lens are focused on a special mirror and reflected to the lens in front of the photoelectric cell.

The case is of cast aluminum, so designed that the entire unit may readily be weather-proofed, if desired, for outdoor use.

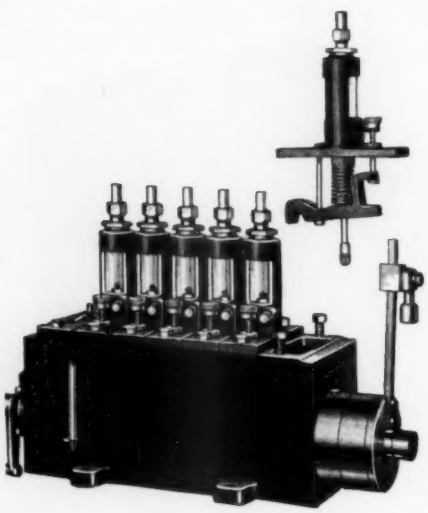
Wagner Split-Phase Motors, Types 44RB and 56RB

Two split-phase motors, the 44RB and the 56RB, have been announced by Wagner Electric Corp., 6444 Plymouth Ave., St. Louis, Mo. Both have been completely redesigned, according to the manufacturer, for quiet, vibrationless, and cool operation. New features include: Drip-proof endplates, wool-yarn lubrication, handy conduit box adjustable in four positions, and a redesigned switching mechanism on the 44RB. The 44RB is available in $\frac{1}{30}$ and $\frac{1}{20}$ hp., and the 56RB in $\frac{1}{8}$, $\frac{1}{6}$, and $\frac{1}{4}$ hp., 1,725 and 1,140 r.p.m., all cycles.



Bowser Fig. 451 Force-Feed Lubricator

A force feed lubricator equipped with liquid-filled sight glasses has been announced by S. F. Bowser & Co., Inc., Fort Wayne, Ind. A single plunger serves the dual purpose of drawing the oil from the reservoir and forcing it in a straight vertical path through the sight glass to the point of lubrication at the end of the feed line. Each pumping unit is individually adjusted and removable while the lubricator is in operation. A simple method of refilling the sight glass has been incorporated. A

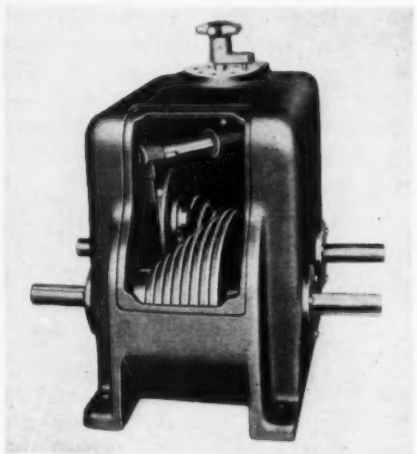


standard lubrication fitting permits injection of the liquid by means of a grease-gun. The new lubricator, designated as Fig. 451, can be furnished with any number of feeds and with any type of driving mechanism required.

General "Multi-Speed" Transmission

A line of "Multi-Speed" change boxes using the Gibbs' V-disk transmission has been announced by General Radial Drill Co., 1765 Elmore St., Cincinnati, Ohio. Slippage should be at a minimum because the idler disk sets up a wedging action in direct proportion to the load it transmits. Speed changes are simply and positively made by means of a star knob on top of the unit.

The grooved cones are of steel, mounted on steel shafts supported by ball bearings. The composition disk runs as an idler between the cones and is the only part to wear, except the ball bearings. The transmission proper runs dry. Shaft ball



bearings are the only points for lubrication, these being served easily from outside. Ratios may be had in eight speed changes up to 9 to 1 and in sizes from $\frac{3}{4}$ to 10 hp., inclusive.

Reading-Pratt & Cady Bar Stock Valves

Globe valves, precision turned from carbon steel in $\frac{3}{4}$-in. and 1-in. sizes are being added to the line of Reading-Pratt & Cady Co., Inc., Bridgeport, Conn. Designed for services where high strength and close control are indicated, these valves have stainless steel, slip-on renewable disks and screw-in seats. Stems are designed and treated for temperature service, the treatment being calculated to assure long life and resistance to corrosion. All other parts are Parkerized inside and out.

Smaller sized carbon steel valves, in both globe and angle patterns, have integral seats and disks; otherwise they are similar to the larger valves. Working pressures are 4000 lb. at 150 deg. F., 600 lb. at 500 deg. F.

In addition to the standard line, the valves can be furnished with indicator

handwheels, lock shield and key, male or female unions, and male and female ends. There is also a manifold type consisting of three valves on a single body.

Rhoads Tannate Special Rounded Belt

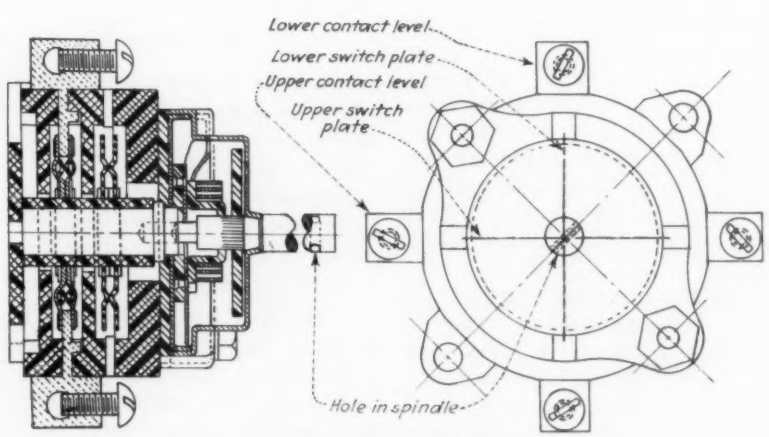
After two years of laboratory tests, J. E. Rhoads & Sons, 35 N. 6th St., Philadelphia, Pa., announce Tannate special rounded belt in sizes from $\frac{1}{8}$ in. to $\frac{9}{16}$ in. in special dispensing boxes. These tests would indicate an average life 20 per cent longer than that of the standard Rhoads Tannate and considerably less stretch in service. Horsepower ratings based upon normal pulley diameters and tensions follow:

Belt Speeds Ft./Min.	Belt Sizes $\frac{3}{16}$"	$\frac{1}{4}$"	$\frac{5}{16}$"	$\frac{3}{8}$"	$\frac{1}{2}$"
500	.13	.18	.25	.34	.62
1,000	.26	.37	.50	.68	1.25
1,500	.39	.55	.75	1.03	1.87
2,000	.52	.74	1.00	1.37	2.50
2,500	.65	.92	1.25	1.71	3.12
3,000	.78	1.11	1.50	2.03	3.75
3,500	.91	1.30	1.75	2.40	4.37
4,000	1.04	1.48	2.00	2.74	5.00

Arrow-Hart & Hegeman Double Pole Switch

A double pole switch, comprising molded bakelite sections built up around switch blades and totally inclosing the operating parts, constitutes the newest offering of Arrow-Hart & Hegeman Electric Co., 103 Hawthorne St., Hartford, Conn. A formed metal housing incloses the actuating movements and the locking plate. All exposed metal parts are cadmium plated. The terminal lugs will take either solid or stranded wire. All material conforms to Navy specifications.

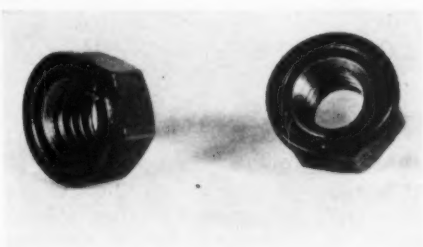
Available in single, double, triple and four pole combinations with various types of operating handles and variable spindle lengths, the switch can be furnished in different circuit combinations to provide for the control of intricate motor and lighting circuits. Size approximately $1\frac{1}{2}$ in. diam. by $1\frac{1}{2}$ in. overall height. All types approved for 10 amp. 250 volts.



Double pole switch in "on" position

Bracketite Combination Lockwashers and Nuts

Assembly of capscrew and lockwasher—or nut and lockwasher—claimed to reduce cost, simplify production, and eliminate possibility of capscrews and nuts getting into products without protective lock washers, is embodied in the "Bracketite" combination lock washer and nuts now being manufactured by National Machine Products Co., 4850 Bellevue Ave., Detroit, Mich. As shown, the lock washer is fastened over a shoulder on the nut, thus enabling it to perform its usual function without being separate from the nut itself. A similar assembly is used for capscrews.



Colmonoy Crystal Products

Colmonoy crystals, free from carbon and tungsten, form the base of the nine Colmonoy products now offered by the Booth Engineering Company, Ltd., 15 Park Row, New York, N. Y. These new crystals do not oxidize at elevated temperatures, are insoluble in the strong acids, have a hardness between nine and ten Moh's scale, a high melting point and a specific gravity about two-thirds of that of mild steel. It is claimed that they do not combine chemically with any element or metal or alloy in the molten condition, so that upon cooling the microscopic crystals are found uniformly distributed in the congealed mass.

Colmonoy inserts consist of Colmonoy crystals in a matrix of tungsten, and as a substitute for diamonds, can be used to advantage on various types of cutting tools. The specific gravity of the inserts is 8.75 as compared to 16.25 for tungsten-carbide. The inserts do not oxidize or crack when heated to a high temperature, and their hardness lies between nine and ten on Moh's scale.

Colmonoy granules have the same composition as the inserts, range from 16 to 60 mesh and are applied to thin-edged tools such as shovels, by spreading them thinly on the surface to be hardened and heating with the oxyacetylene flame until the granules are cemented to the base metal, giving an extremely abrasion-resisting cutting edge.

Colmonoy tubes consist of small inserts in a steel tube, and are applied much the same as other similar products.

Colmonoy hard facing rods come in two different types. The No. 1 rod, applied by either gas or electric welding, makes a hard facing for general all around use. The No. 6 rod has a high crystal content in a matrix of iron, nickel and molybdenum. Though not as hard, it is more abrasion-resisting than No. 1 rod, and is applied with the oxyacetylene torch.

Colmonoy overlay compound is for carbon arc application only, giving an extremely hard and abrasion-resisting overlay. Spread evenly over the

surface to a depth of about $\frac{1}{8}$ in., and fused in with a small sharp carbon pencil, one layer gives a hardness of Rockwell C62 to C66, while two layers will give a hardness ranging from C65 to C69.

Colmonoy machine tool overlay is for tipping lathe tools by welding on from the rod form with the oxacetylene torch. According to the manufacturers, it has demonstrated its superiority in the machining of the tougher grades of alloy steel.

Solid cast Colmonoy toolbits, furnished in standard sizes, have the same composition as the cast Colmonoy overlay rod used for tipping.

Colmonoy acid-proof overlay rod has been developed principally for facing machinery parts which come in contact with sulphuric acid. This material contains a high percentage of crystals in a matrix of cobalt, has a Rockwell hardness of C45, has a relatively low melting point, and flows onto the base metal free from porosity. Its abrasion-resistance is high owing to the high crystal content.

New Books and Publications

GENERAL ENGINEERING HANDBOOK

[*C. E. O'Rourke, editor-in-chief*]. 883 pages, 5x8 in. Published by McGraw-Hill Book Co., Inc., 330 West 42d St., New York, N. Y. Price $4.00.

By condensing or omitting tables of manufacturing standards, such as the standard sizes of bolts, nuts, pipes and similar items, and by omitting descriptive matter and items of a specialized nature, the editor of this handbook has been able to present the fundamentals of engineering in one compact volume. The subject matter includes the three major divisions of engineering, namely civil, electrical, and mechanical. Twenty-nine associate editors contributed.

The first two sections of the book contain the mathematics and mathematical tables of engineering. This is followed by tables of weights and measures. Other sections include engineering materials, mechanics, hydraulics, graphic statics, framed structures, reinforced concrete, surveying, railway locations and curves and earth work, highways, water supply and water power plants, sewage disposal. The section dealing primarily with mechanical engineering includes machine elements, thermodynamics, engines, pumps, compressors, heating and ventilating, refrigeration, and power transmission. There is also a chapter on welding. In the electrical engineering section there are two sections on the fundamental principles and measurements of electrical quantities, followed by sections on electrical machinery, power plant equipment, and electric power transmission and distribution.

Probably the greatest value of the book lies in the fact that an engineer in one division of the work finds in this one book the fundamentals and the specific facts relating to the other branches of the profession.

GRAPHICS

[*Seibert Fairman and Chester S. Cutshall*] First edition. 131 pages, $5\frac{3}{4}$x9 in. Clothboard covers. Published by McGraw-Hill Book Co., 330 W. 42d St., New York, N. Y. Price, $1.75.

The authors cover graphic statics both as applied to stationary structures and to machines. The subject is handled in a logical manner, beginning with definitions and then following with a chapter on fundamental principles wherein are explained the simple parallelograms of forces and the resolution of forces. In this second chapter is shown the manner of resolving the various possible combinations of forces. Following this is a section devoted to the solution of problems relating to trusses, after which cranes, derricks, and similar structures are considered. The last chapter deals with machines. Sliding surfaces, journal friction, gear pressures, reactions at rolling surfaces, and machine efficiency are each considered in a fundamental manner. In an appendix is presented the graphical solution for the centroid of an area, moment of inertia, and bending moments.

One of the convenient features of the book is the manner of giving the examples, together with their solutions. Numerous problems are also presented and the answers given so that the reader will be able to check his work.

Air Filters

[*American Air Filter Co., Inc., Louisville, Ky.*] "American Air Filters in Industry" describes the broad scope of "dust engineering" in 26 pages and classifies specific applications and installations.

Ball Bearings

[*Auburn Ball Bearing Co., Rochester, N. Y.*] A new reference manual describes the bearings, gives mounting instructions, dimension limits, lists of stock sizes and capacity tables. Special bearings are also illustrated.

Capacitor Motors

[*The Ideal Electric & Mfg. Co., Mansfield, O.*] Bulletin No. 210 gives full description and details of the Noel polyphase capacitor motor, its capacitor equipment, and its characteristic curves.

Flexible Couplings

[*American Flexible Coupling Co., Erie, Pa.*] Bulletin No. 102 presents the principles underlying American flexible couplings, dimensions, ratings and prices together with halftone illustrations of specific applications.

Gear Units

[*Farrel-Birmingham Co., Buffalo, N. Y.*] Bulletin No. 425 covers Farrel-Sykes high-speed gear units, giving hp. ratings, designs and other engineering data.

Molybdenum

[*Climax Molybdenum Co., 295 Madison Ave., New York, N. Y.*] "Mo-lyb-den-um in 1931," describes developments in the use of molybdenum during the year and explains a number of its applications.

Multi-V Drives

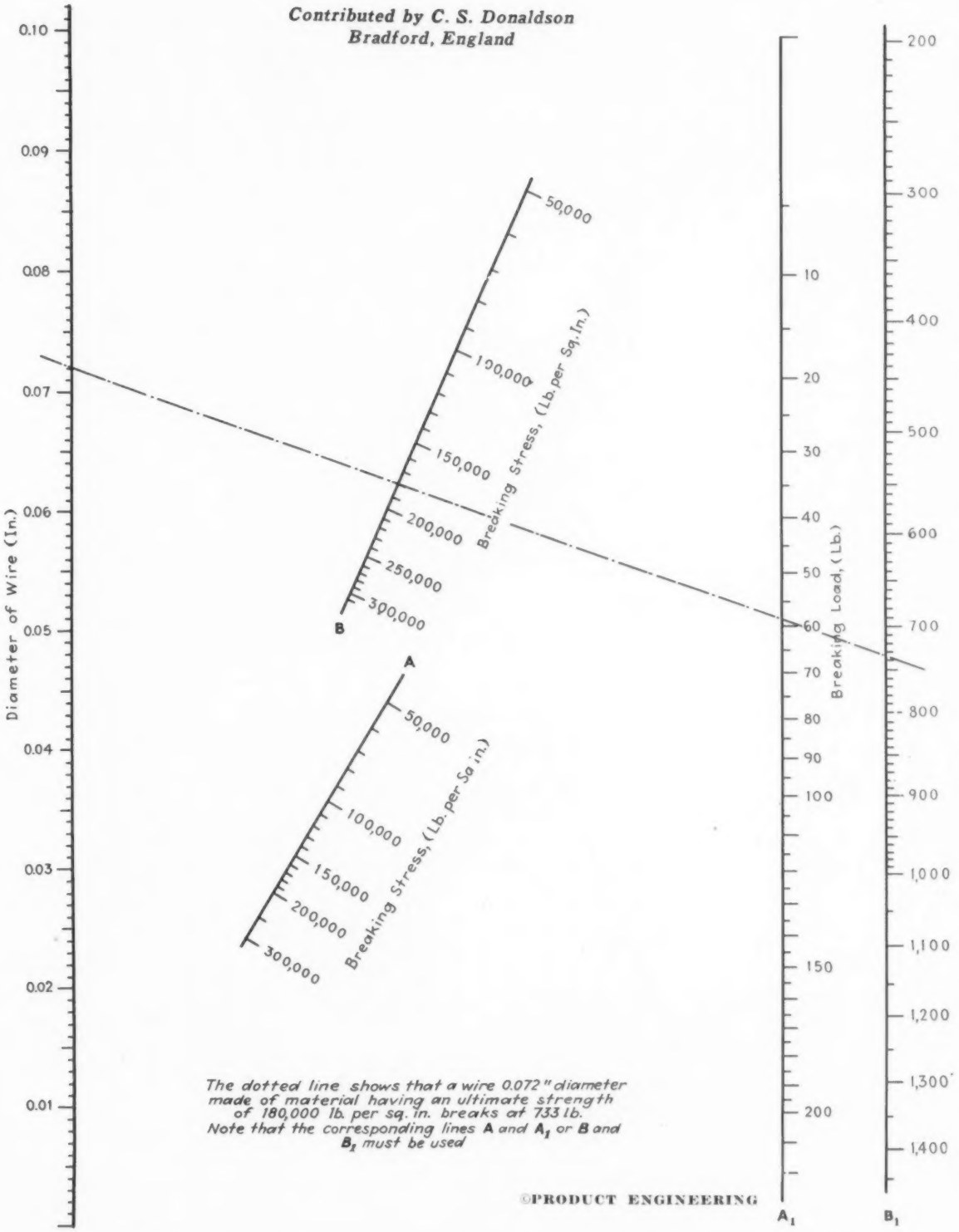
[*Worthington Pump & Machinery Corp., Harrison, N. J.*] Bulletin L-400-B2A has for its title, "Multi-V Drives," and covers the Worthington application of Goodyear rubberized cord belts to V-groove sheaves.

Pressure Gage

[*Bristol Co., Waterbury, Conn.*] Catalog No. 1011 covers a new, direct-reading, absolute pressure gage for control and operation of apparatus relying on the maintenance of a high and constant vacuum.

Breaking Load of Round Wires

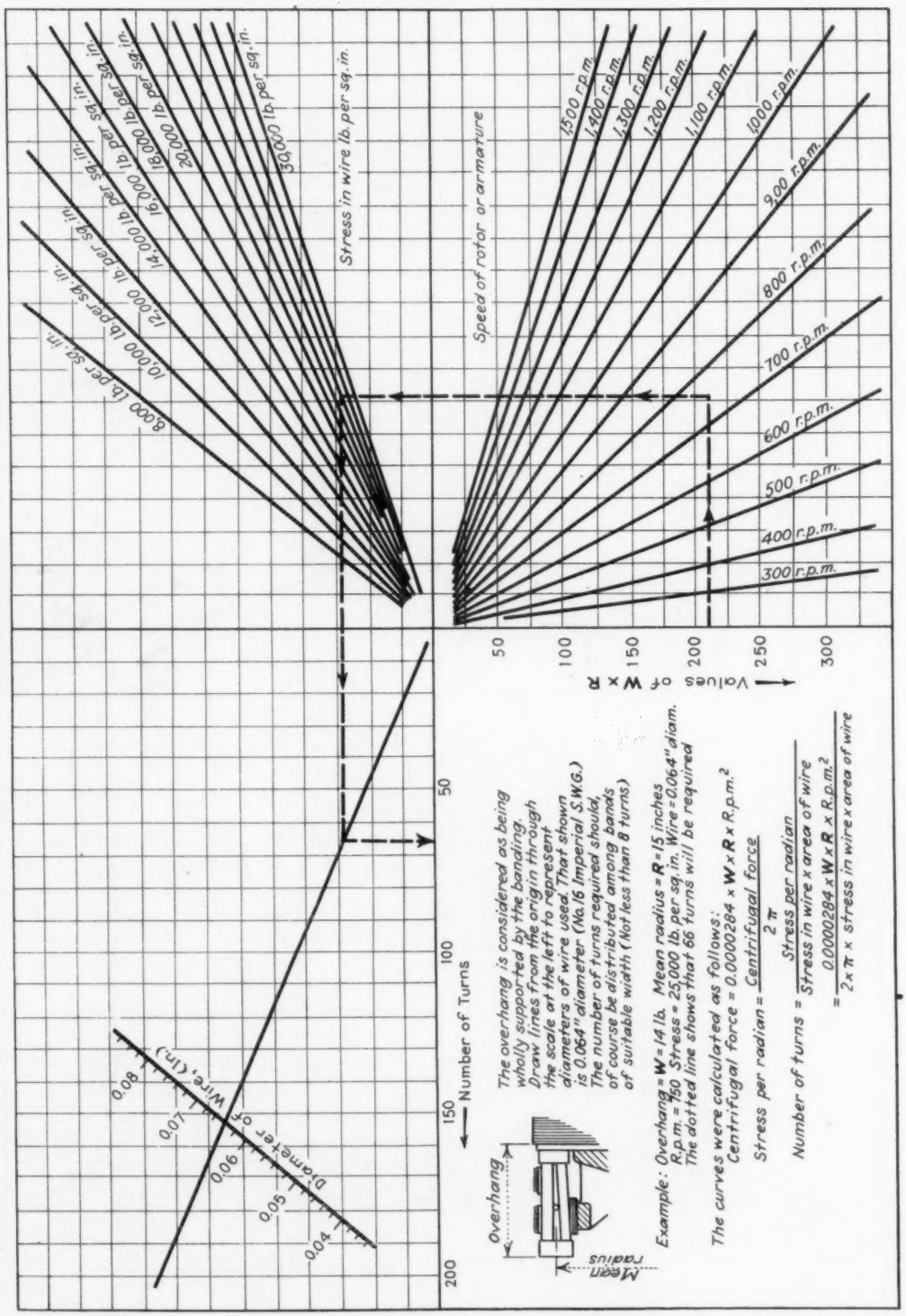
Contributed by C. S. Donaldson
Bradford, England



The dotted line shows that a wire 0.072" diameter made of material having an ultimate strength of 180,000 lb. per sq. in. breaks at 733 lb. Note that the corresponding lines A and A_1 or B and B_1 must be used

REFERENCE BOOK SHEET

Turns of Banding Wire for Armature End Windings


Stress in wire lb. per sq. in.
30,000 lb. per sq. in.
20,000 lb. per sq. in.
18,000 lb. per sq. in.
16,000 lb. per sq. in.
14,000 lb. per sq. in.
12,000 lb. per sq. in.
10,000 lb. per sq. in.
8,000 lb. per sq. in.
Speed of rotor or armature
1,500 r.p.m.
1,400 r.p.m.
1,300 r.p.m.
1,200 r.p.m.
1,100 r.p.m.
1,000 r.p.m.
900 r.p.m.
800 r.p.m.
700 r.p.m.
600 r.p.m.
500 r.p.m.
400 r.p.m.
300 r.p.m.
Values of W x R
50
100
150
200
250
300
Number of Turns
50
100
150
200
Diameter of Wire (in.)
0.08
0.07
0.06
0.05
0.04
Overhang
Mean radius
The overhang is considered as being wholly supported by the banding. Draw lines from the origin through the scale at the left to represent diameters of wire used. That shown is 0.064" diameter (No.16 Imperial S.W.G.) The number of turns required should, of course be distributed among bands of suitable width (Not less than 8 turns.)
Example: Overhang = W = 14 lb. Mean radius = R = 15 inches
R.p.m. = 750 Stress = 25,000 lb. per sq. in. Wire = 0.064" diam.
The dotted line shows that 66 turns will be required
The curves were calculated as follows:
Centrifugal force = 0.0000284 × W × R × R.p.m.²
Stress per radian = Centrifugal force / 2π
Number of turns = Stress per radian / (Stress in wire × area of wire)
= 0.0000284 × W × R × R.p.m.² / (2π × stress in wire × area of wire
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REFERENCE BOOK SHEET